Industrial QUALITY CONTROL

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In This Issue

Inspection Errors Cost Money

QC in the Industrial Control Laboratory

Is Automatic Quality Control a Reality?

Acceptance Plan Applied to the Army's Jeep

Two-Way X-Bar Chart

QUALITY
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Scientific Methods

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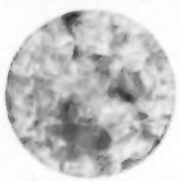

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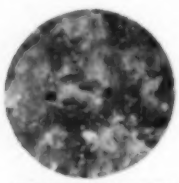

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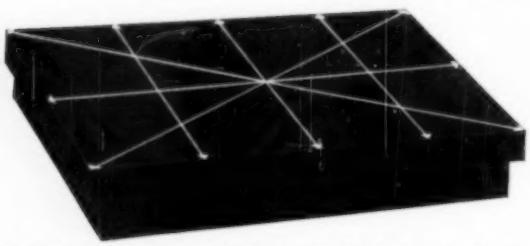

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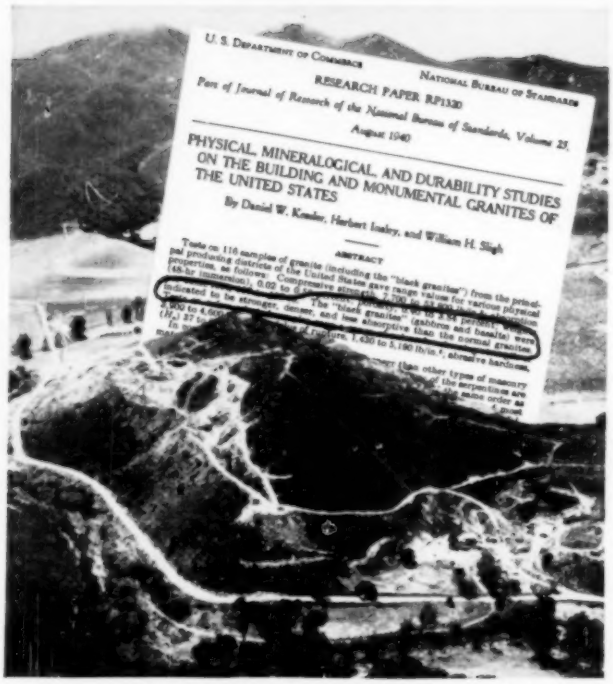
U. S. Department of Commerce — National Bureau of Standards

RESEARCH PAPER RP1320

Part of Journal of Research of the National Bureau of Standards, Volume 25, August 1940

PHYSICAL, MINERALOGICAL, AND DURABILITY STUDIES ON THE BUILDING AND MONUMENTAL GRANITES OF THE UNITED STATES

By Daniel W. Kessler, Herbert Insley, and William H. Sligh

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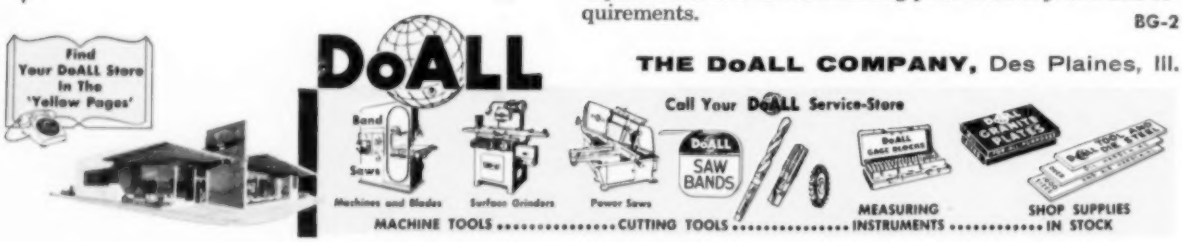

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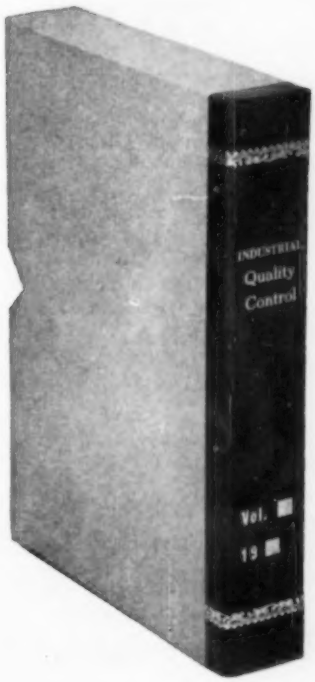

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Contents

ARTICLES

Effect of Inspection Errors on Waste and on Quality of Outgoing Product
J. Edward Jackson 5
This article presents simple formulas for estimating the costs of inspection errors, where these are apt to be large. The problem, when inspections are based on measurements, is negligible, but becomes important when the inspections concern qualitative criteria and hence require judgments.

Effective Quality Control Program for the Industrial Control Laboratory
Frank W. Kroll, Jr. 9
Discussing the control laboratory problem of Esso's Bayway Refinery, the author shows that statistical design of tests is an economic necessity. An alternative—multi-testing—is prohibitively costly unless you settle for a much lower quality level.

Automatic Quality Control, Pipe Dream or Reality?
T. Williams Roberts, Jr. 14
The author says it is a "must." With industry bringing more and more problems to their quality control departments for analysis, automatic processing of data is the answer to keep quality engineers from looking like manual telephone operators.

Acceptance Plan for Automotive Vehicles
B. L. Hansen 18
This article discusses the application of MIL-STD-105A acceptance sampling procedures to government purchases of the "jeep."

An Application of a Two-Way X-Bar Chart
Peter E. Weis 23
The two-way X chart was developed to control two unrelated variables with a single control chart. Its application to the manufacture of an automotive circuit breaker problem is discussed.

DEPARTMENTS

From the President's Desk, *Your Future—Our Future* 4
Section Briefs 27
Section Calendar 30
Supervisor's Circle 33
1957 Shewhart Medal Nominations 35
Product Education Service 36
Clinics, Conferences, and Courses 37
Book Reviews 38
Correction Notice 39
Positions Available 39, 40
Consulting Service 40

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From the President's Desk

Your Future—Our Future

Last January this column was devoted to discussion of a problem that still faces us today.

The problem is that of finances. For the past several years it has been apparent to the officers that to keep pace with the increasing expense of our service to members, additional income would be needed.

We have been able to continue this long only through the generosity of some of our sections, divisions and individual members. We cannot continue to operate the Society on this basis —and we feel sure the members of ASQC do not want us to try to operate in this fashion.

Last year the Board of Directors recommended, subject to membership approval, an increase in society dues. It was a modest increase. For members, the recommendation called for a $2.00 increase. For senior members and fellows, the increase recommended was $3.00.

However, the increase failed by a small margin to obtain approval at the time of the April ballot.

We believe the failure was due to a lack of understanding of the problem. This being true, we must accept the responsibility for failing to communicate properly with the membership; for insufficient promotion of the advantages of membership; for not pointing out the great potential of ASQC.

Every effort has been made to avoid a dues increase. We have effected economies in operation; we have developed additional sources of revenue. However, in spite of these efforts, the operating expense still exceeds the income from membership dues and publications.

In a few months a new proposal for an increase in dues will be presented for membership approval. In the interim we plan to do a better job of giving you the facts. Through the medium of this and other pages in *Industrial Quality Control*, through our new bulletin ASQC Intercom, and through personal contacts from the officers, directors and district representatives we hope to present the picture to you. We are confident that if you know the whole story you will vote for the increase. Such approval will indicate your desire to have ASQC expand as a professional society and is, indeed, necessary to continued strengthening of professional stature.

Sincerely,

Leon Bass

Effect of Inspection Errors on Waste and on Quality of Outgoing Product

J. EDWARD JACKSON

Eastman Kodak Company Rochester, N.Y.

Introduction

In any inspection system where the decision to accept or reject an item is left to the judgment of the individual inspector, even the best inspector will occasionally make a mistake. If the inspection procedure involves a quantitative measurement such as gaging or weighing, this should not be a very frequent problem unless the testing and measurement variability is large. That is, except for gross errors such as recording errors, an inspector could do as well as his testing equipment will allow him.

However, if the inspection procedure is qualitative in nature and is in the form of, for example, a sensory difference test where a sample item is compared to a standard by taste, smell, feel, or appearance, then these inspection errors can become sizable, as the inspector must make a *judgment* each time an item is inspected. For inspection procedures of this sort the standard itself is established on a sensory basis, and the inspection of individual items is somewhat arbitrary depending on the inspector's interpretation of the standard.

Most industries faced with this situation usually have intensive training courses for their inspectors, as well as refresher or follow-up programs, because it is important that all of their inspectors interpret a standard as nearly the same as possible. The degree to which an inspector can make correct decisions depends on the training program, the type of inspection employed, and the type of judgment that must be made. It is therefore necessary in these cases for management or the inspection supervision or both to know what the effect of inspection errors will be, both on waste and on the quality of the outgoing product.

An inspector can make two types of errors: (1) he may reject an item of acceptable quality and (2) he may pass an item that is defective. These differ slightly from the customary Type I and Type II errors usually associated with quality control in that the latter are functions of the sample size and the variability incurred in the sampling program. Inspection errors, however, will occur regardless of whether a sampling plan or 100 percent inspection is used. The discussion that is to follow is concerned with 100 percent inspection where all material that is rejected is replaced.

Definitions

Theoretical Waste is a measure of the amount of defective material in the process and is an index of the scrap or rework material if the inspection function were 100 percent accurate. This will be denoted by T = percent of inspected material that is defective. (In quality control literature this would be referred to as the true percent defective and would carry the symbol p'.)

Actual Waste is a measure of the actual amount of scrap or rework material. The difference between the actual waste and the theoretical waste is a function of the inspection errors. Let A = percent of inspected material that is rejected.

Defectives Missed is a measure of inaccuracy of the inspection function in identifying rejectable material. Let M = percent of defective material that is passed.

Passable Rejects is a measure of the unnecessary waste caused by rejecting passable work. Let P = percent of rejected material that is acceptable.

Outgoing Defectives is a measure of the defective material reaching the customer. Let D = percent of passed material that is defective.

In industry, generally, management knows the actual waste figure (A). By taking random samples from the material that has already been inspected and passed, an estimate of the outgoing defectives (D) can be obtained, and by sampling the rejected material, the percent of passable rejects (P) can be obtained. From all of these data a measure of M, the percent of defectives missed can be obtained, and finally theoretical waste (T).

Development of Relationships

As stated above, the difference between actual and theoretical waste is a function of passable rejects and of defectives missed. When material of passable quality is rejected the actual waste is higher than the theoretical waste. When defective material is passed the actual waste is lower than the theoretical. The degree to which these errors affect waste and the quality of outgoing material will be shown below.

Management is often concerned with the combined effect on outgoing quality of changes in the quality of the product coming into the inspection area and changes in the quality of inspection. Figure 1 shows the relationship between the outgoing defectives (D) and the percentage of defectives missed (M) for various theoretical waste levels (T) when the passable rejects level is held constant at 6 percent. This relationship is nonlinear, with the result that the higher the T-level the greater the reduction in percent of D for a given reduction in M. For example, a decrease in M from 40 percent to 30 percent will result in a 4½ percent reduction in D for a 40 percent T-level, but only a 3¼ percent reduction for a 30 percent T-level. Also, because of this nonlinear relationship, the greater the improvement in M the greater the decrease in D. For example, at a T-level of 40 percent, a decrease in M from 40 percent to 30 percent will reduce D by 4½ percent while a further decrease from 30 percent to 20 percent will reduce D by 5 percent. Since management usually knows the actual waste figure and can obtain an estimate of the defectives missed, Fig. 2 will be of use in determining from the information available what the effect on outgoing quality would be for changes in the quality of inspection. This figure again assumes a constant P-level of 6 percent.

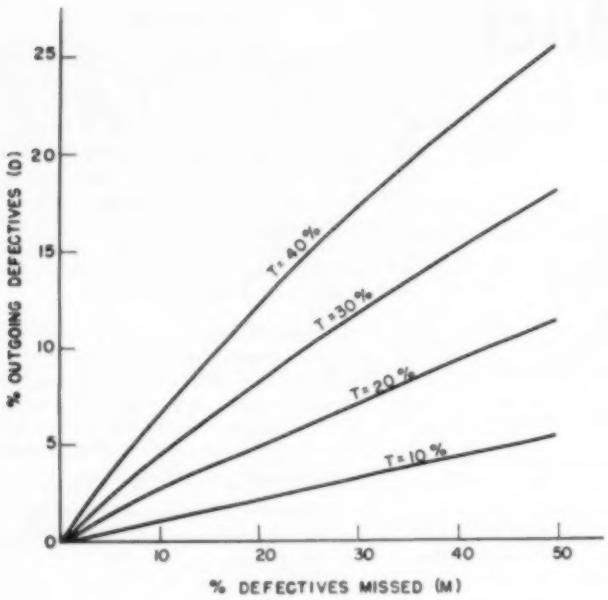


Figure 1—Outgoing Defectives plotted against Defectives Missed at various levels of Theoretical Waste (T) with Passable Rejects level of 6 percent.

Management should also be interested in finding out the true or theoretical waste picture once A, D, and P are known. Figure 3 shows the relationship between actual and theoretical waste for given levels of outgoing defectives when the P-level is 6 percent. For example, when the actual waste level (A) is 10 percent with 15 percent outgoing defectives (D), the T-level is 23 percent. Thus the waste has been understated by 13 percent because a large proportion of the defects has been missed. This difference between theoretical and actual waste will result in many customer complaints and much loss of good will, which, in the long run, will outweigh any waste saving.

The basic problem throughout this discussion is, of course, the effect of these two types of inspection errors. The effect of defectives missed (D) on the difference between actual and theoretical waste can be seen in Fig. 4. If the T-level were 40 percent, and 50 percent of the defectives were missed (M), A would be 21¼ percent. If M were dropped to 30 percent, A would be increased to nearly 30 percent. If any defectives are missed, the waste is understated and becomes greater as M increases.

In the preceding examples the passable rejects level was held to a constant 6 percent. Figure 5 shows the relationship between actual and theoretical waste for various levels of passable rejects (P) when 40 percent of the defectives are missed. For a T-level of 40 percent, an increase in P from 0 to 10 percent will increase A by 2½ percent. Thus the passable rejects factor contributes to an overstatement of the waste picture.

In the Appendix the mathematical relationships between the various terms are shown, and examples are given. Figures 6 and 7 contain nomographs with which all possible relationships between each of these measures can be determined. Since these nomographs cover the entire range from 0 to 100 percent, they may be used for any inspection program in which the decision is to accept or reject.

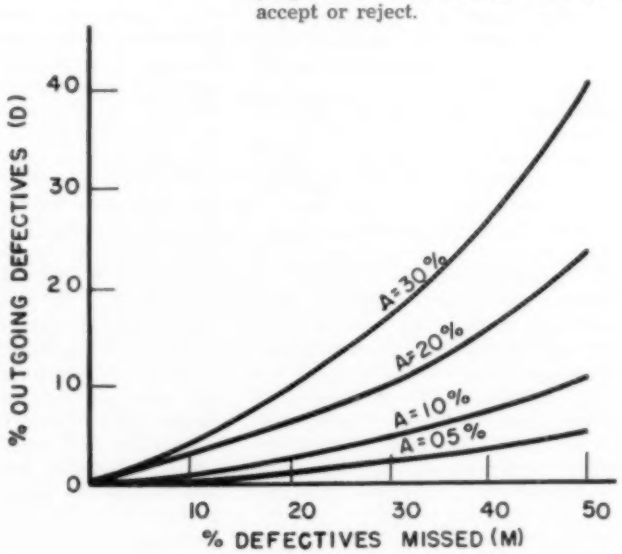


Figure 2—Outgoing Defectives plotted against Defectives Missed at various levels of Actual Waste (A) with Passable Rejects level of 6 percent.

APPENDIX

Derivations of Formulas

By the use of parametric equations, the following relationships can be established between two or more of these variables until all are interrelated:

(1) Theoretical waste is the actual waste adjusted for passable rejects and defectives missed.

$$T = \frac{A(1-P)}{1-M}$$

Thus, as M and P approach 0, T will approach A. This relationship is shown in nomograph form in Fig. 6.

Example: If the actual waste level is 20 percent, passable rejects level is 6 percent, and 40 percent of the defectives are missed, then the theoretical waste is

$$T = \frac{(A)(1-P)}{1-M} = \frac{(0.20)(1-0.06)}{0.60}$$

$$= 0.313 \text{ or } 31.3\%.$$

This relationship does not hold for $A = 0$ and for $A > \frac{1-M}{1-P}$. It can be rewritten to solve for, say, A in which case the equation is:

$A = \frac{T(1-M)}{1-P}$. This does not hold for $T = 0$ or $T > \frac{1-P}{1-M}$.

(Figure 6 still applies.)

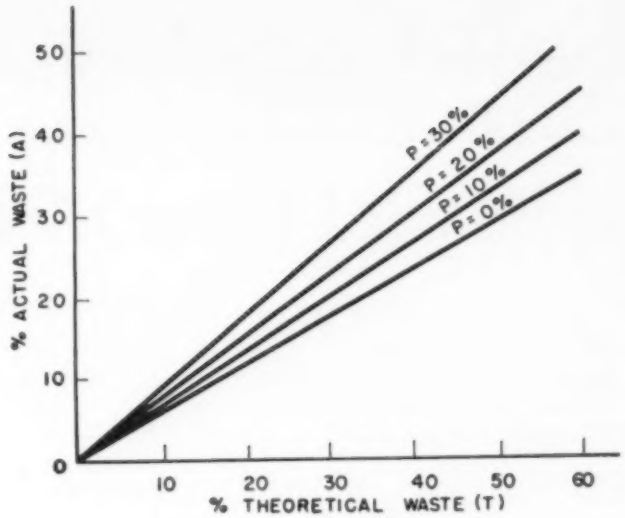


Figure 5—Actual Waste plotted against Theoretical Waste at various levels of Passable Rejects (P) with Defectives Missed at 40 percent.

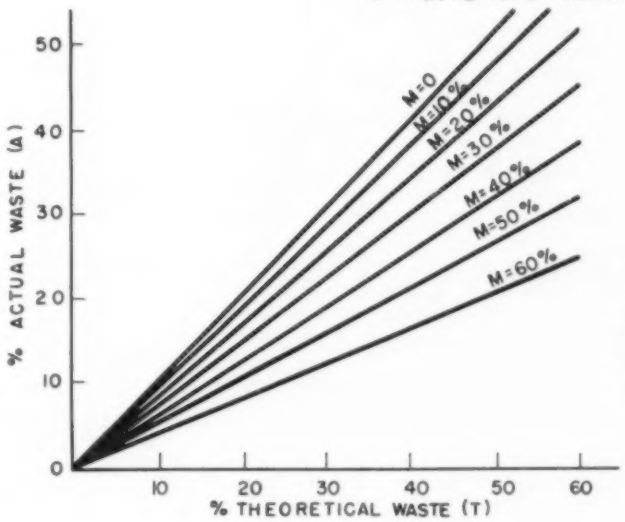


Figure 4—Actual Waste plotted against Theoretical Waste at various levels of Defectives Missed (M) with Passable Rejects level of 6 percent.

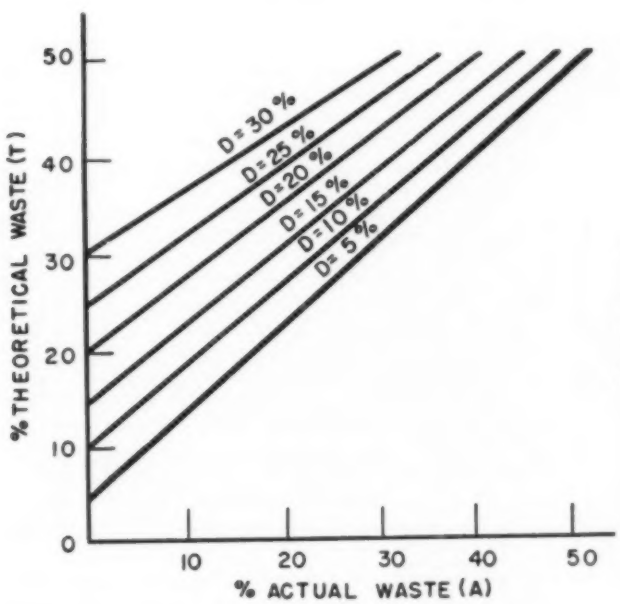


Figure 3—Theoretical Waste plotted against Actual Waste at various levels of Outgoing Defectives (D) with Passable Rejects level of 6 percent.

(2) Outgoing defectives is the ratio of defective material shipped to total material shipped.

$$\text{Outgoing Defectives} = \frac{\text{Defective Material Shipped}}{\text{Total Material Shipped}}$$

$$= D = \frac{TM}{1-A}$$

In terms of *actual waste* only:

$$D = \frac{AM(1-P)}{(1-A)(1-)}$$

A nomograph for this equation is shown in Fig. 7.

Example: If the actual waste were 20 percent, 40 percent of the defectives were missed and passable quality = 6 percent, then:

$$D = \frac{(0.20)(0.40)(0.94)}{(0.80)(0.60)}$$

$$= 0.157 \text{ or } 15.7\%$$

This equation can be solved for A, M, or P as follows:

$$A = \frac{D(1-M)}{D(1-M) + M(1-P)}$$

$$M = \frac{D(1-A)}{D(1-A) + A(1-P)}$$

$$P = 1 - \frac{D(1-M)(1-A)}{AM}$$

Figure 7 can be used for all of these relationships. In terms of *theoretical waste* only:

$$D = \frac{TM(1-P)}{(1-P) - T(1-M)}$$

The most important use of this relationship is in the determination of the theoretical waste when M, P, and D are known:

$$T = \frac{D(1-P)}{D(1-M) + M(1-P)}$$

Other relationships:

$$P = 1 + \frac{DT(1-M)}{TM - D}$$

$$M = \frac{D(1-P-T)}{T(1-P-D)}$$

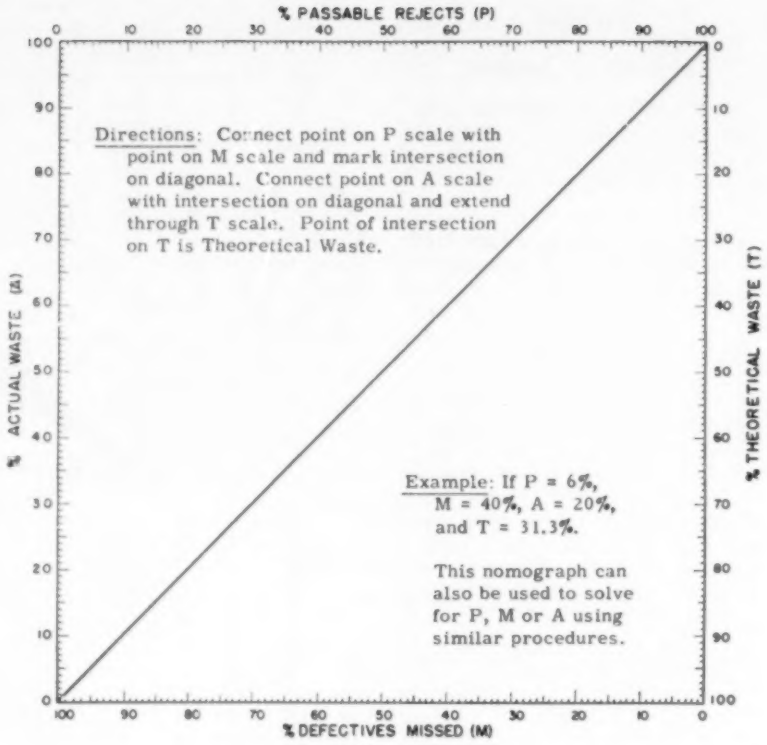

% PASSABLE REJECTS (P)
% ACTUAL WASTE (A)
% THEORETICAL WASTE (T)
% DEFECTIVES MISSED (M)
Directions: Connect point on P scale with point on M scale and mark intersection on diagonal. Connect point on A scale with intersection on diagonal and extend through T scale. Point of intersection on T is Theoretical Waste.
Example: If P = 6%, M = 40%, A = 20%, and T = 31.3%.
This nomograph can also be used to solve for P, M or A using similar procedures.

Figure 6—Nomograph for $T = \frac{A(1-P)}{1-M}$

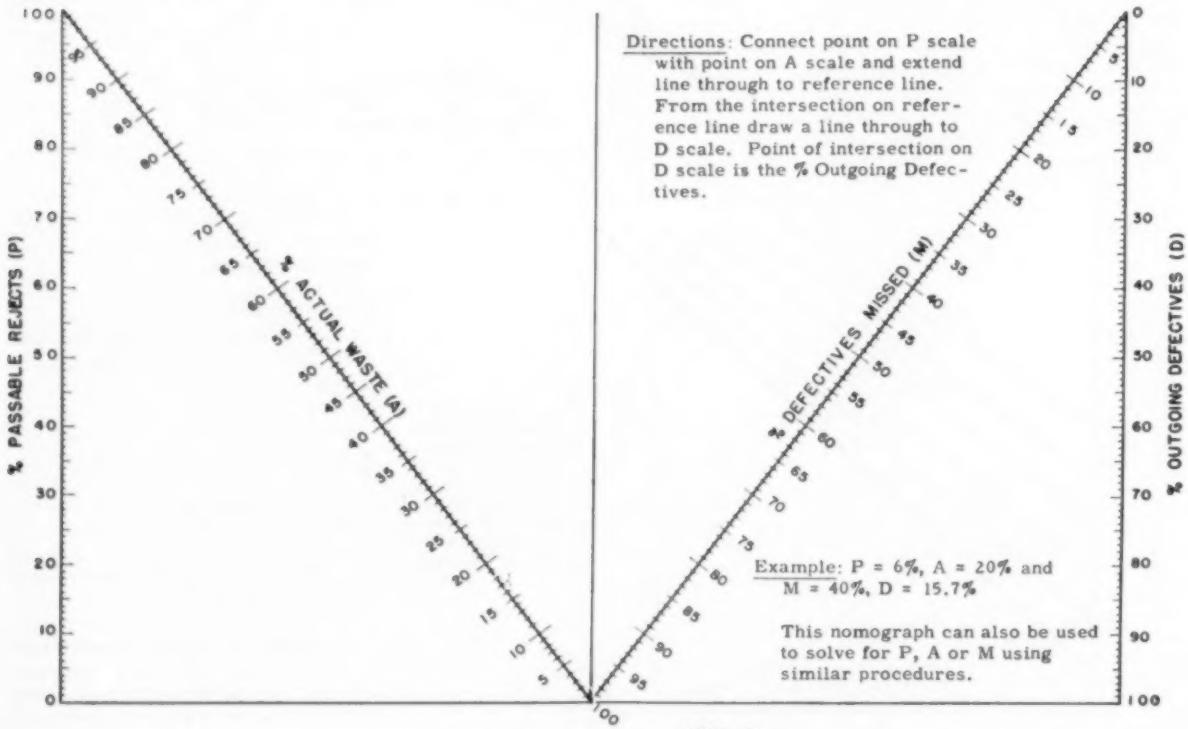

% PASSABLE REJECTS (P)
% ACTUAL WASTE (A)
% DEFECTIVES MISSED (M)
% OUTGOING DEFECTIVES (D)
Directions: Connect point on P scale with point on A scale and extend line through to reference line. From the intersection on reference line draw a line through to D scale. Point of intersection on D scale is the % Outgoing Defectives.
Example: P = 6%, A = 20% and M = 40%, D = 15.7%
This nomograph can also be used to solve for P, A or M using similar procedures.

Figure 7—Nomograph for $D = \frac{AM(1-P)}{(1-A)(1-M)}$

Effective Quality Control Program for the Industrial Control Laboratory

FRANK W. KROLL, JR.

Esso Standard Oil Company, Linden, N. J.

Esso Standard's Bayway Refinery has pioneered in the effective application of statistical quality control to improve the management of the control laboratory. While this application is only the first phase of a broad program the reader will find a well integrated laboratory quality control program described in this article. The net result of making the "quality control function" an integral part of the normal line-supervisory responsibility has been improved testing reliability for many standard, well established chemical and physical test methods.

Introduction

An oil refinery produces a large number of products and performs intermediate and finished-product inspections by the thousands every day. To do this inspection job, many tests are employed by staffs of trained laboratory technicians. The measurement of product quality has become increasingly important in the post-war years along with an increasingly competitive market for petroleum-refined products. Lack of reliable product quality measurements, in this kind of situation, may be responsible for excessive "product-quality giveaway" and improvement in the accuracy and precision of test methods leads to real dollar savings to a refinery.

It was primarily for this reason that two years ago, organization and direction was given to the use of statistical quality control as a management tool to improve the reliability of laboratory inspection results. Alternate ways of accomplishing our objective were considered. Multi-testing (analyzing enough replicate tests to reduce the standard deviation of the reported result), development of new test methods, increased emphasis on laboratory technician training, revision and simplification of tests, and the rewriting of test procedures were all tried; none of these approaches accomplished the job of improving and maintaining work-quality effectively.

It is the purpose of this article to describe the overall laboratory quality control program and to point to some of the important details which have a bearing on the success of such a program.

Management Philosophy of the Program

The single most important factor which prevents a quality control program from becoming a one-shot affair (usually in the form of a committee activity) is the continuing interest and patronage of top-management. To accomplish this, management must be "inspired" by a purposeful and practical philosophy.

For the industrial inspection laboratory, this philosophy must, of necessity, involve all personnel concerned with the production of the "laboratory commodity—the inspection result." It must involve, in particular, those who dispense this commodity to the customers—the line-supervisory foremen. It is axiomatic that continued acceptance of the commodity by customers depends on the continued high-quality of the daily routine inspection result.

With these concepts in mind, it was decided to fortify the laboratory foremen with a continuous system of measuring the quality (reliability) of routine inspection result—in short, to give the foremen the laboratory control chart as an efficient, low-cost "extra man" to monitor the work-quality of the personnel and equipment turning out these results. The important feature of this philosophy is that, contrary to some of the quality control programs described in recent literature, the laboratory foremen did not become the object of control, but rather became responsible for it. Under these circumstances, the overall "quality consciousness" of all laboratory personnel was improved and maintained.

Foreman Training Course

Since the responsibility of laboratory work-quality rests with the foremen, it was decided to concentrate training efforts on this group. A curriculum was designed to instruct these men in the theory, mechanics, and necessary calculations to set up and maintain laboratory control charts; a copy of the program outline may be found in Table I.

The formal instruction consisted of four 1½ hour sessions. This was handled by two university professors actively engaged in the field of statistical quality control. The lecture presentations were pitched at the practical level, supplying only the minimum of statistical theory. The sessions were spaced two weeks apart to allow practice of the techniques between classes; most of the examples used during class were drawn from current laboratory data.

An intensified follow-up program was carried out after completion of the formal instruction; this was

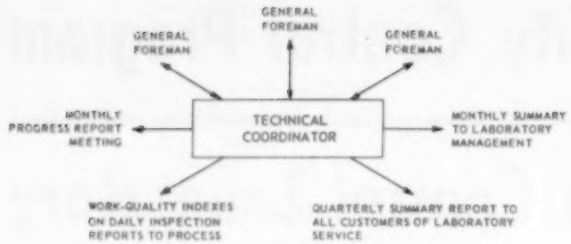

GENERAL FOREMAN
GENERAL FOREMAN
GENERAL FOREMAN
MONTHLY PROGRESS REPORT MEETING
TECHNICAL COORDINATOR
MONTHLY SUMMARY TO LABORATORY MANAGEMENT
WORK-QUALITY INDEXES ON DAILY INSPECTION REPORTS TO PROCESS
QUARTERLY SUMMARY REPORT TO ALL CUSTOMERS OF LABORATORY SERVICE

Figure 1—Organization for Effective Quality Control

assigned to a technical coordinator. It consisted of technical assistance to compile data, set initial control chart limit lines, and provide a system of communication to laboratory management on the progress of all active control charts. It is believed that this intensified follow-up was in large part responsible for the continued interest and improved effectiveness of the foremen in translating the subjects of the lectures into practical applications.

Organization and Communication

Naturally the effectiveness of a quality control program must be maximized by an efficient system of communication from top to bottom of the laboratory organization as well as between the laboratory and its customers. Figure 1 illustrates the organization which was set up to do this job. Below are described the various activities which have been effective in keeping the program vigorous and continually expanding:

1. Preparation of a monthly summary table on the status of all active control charts by the general foremen of the laboratory control groups to the laboratory head. A copy of this is also sent to the technical coordinator. The assignment to prepare this report has clearly left the responsibility for work-quality in the hands of the foremen and has provided the incentive to keep this vigilance continuous.

2. The technical coordinator calls a monthly meeting of the general foremen, technical supervisors, and laboratory head to discuss mutual problems and progress made. Special problems concerning specific tests are brought to the attention of the foremen by the technical coordinator. This meeting has served to tie together the individual programs in each control group as well as to keep management directly informed as to the progress of the overall program.

3. Each laboratory control group places the current maximum allowable testing error on the daily summary inspection report sent to the process operating personnel; these statistics are supplied by the technical coordinator. Specifically, each inspection reported to process personnel is accompanied by a statistic defining the maximum allowable difference between two independent tests on the same sample. This difference is the standard deviation multiplied by $2\sqrt{2}$. This communication is considered to be very important, since (1) it relates testing reliability to a specific result received by process personnel in non-statistical language and (2) it provides an on-the-spot basis for judging the wisdom of "another sample" if the first result reported is not a "desirable" one. Our records show this action has reduced the number of second and third samples requested by process personnel to "check the first figure."

4. The technical coordinator prepares a complete quarterly tabulation of current standard deviations of test methods covered with control charts. This letter has been effective as a guide to technical personnel in making decisions as to the validity of product quality differences reflected by plant-test data. In addition, it provides reliable work quality indexes of our laboratories which may be compared with those of other company laboratories.

TABLE I—Training Program Outline

First Session:	*Fundamental Concepts* a. demonstration with models and gadgets b. definition of "quality" and "statistics" implied in the title c. patterns of "normal" variation
Second Session:	*Types of Variation* a. frequency distribution b. demonstration of kind of data used c. concept of "population" and sampling for an estimate of variation
Third Session:	*The Control Chart for Variables* a. application in the laboratory 1. standard sample 2. for duplicate analyses (one example for each type) b. applications in the plant—demonstration with case history
Fourth Session:	*The Control Chart (continued)* a. for moving average and range b. discussion of mechanics for maintaining charts—illustrated with advanced case histories

Procedure of Activating Control Charts

A general, step-wise procedure has been followed in setting a control chart into routine operation. The following describes the sequence of events that has been followed:

1. Assignment to activate a control chart for a specific test method to a foreman by the laboratory head.

2. A system of accumulating data is set up by the foreman. This is designed so that control chart limit lines can be set in about 2-4 weeks.

3. Control chart limit lines are calculated and drawn. The chart is displayed at the site of the equipment used by the laboratory technician. This step usually involves the services of the technical coordinator of all chart activity.

4. Subsequent analyses for control chart purposes are scheduled and the data are plotted as accumulated by the foreman. It is this activity by the foreman that has been responsible for improvement in test reliability. With the chart displayed on site, a simple observation of the chart by the foreman for out-of-control points has made rapid corrective action possible. Since points appear on most charts at least once every two days, changes in work-quality due to different technicians have permitted judicious selection of technicians requiring further training. Enforcement of adherence to standard procedures and use of proper equipment have also resulted in precision improvement.

5. Control limit lines are recalculated once a month. Changes in level of precision are relayed to the coordinator and reported once a month to laboratory management.

Figure 2 illustrates the typical history of a control chart. For purposes of illustration, average and control limit lines have been drawn for all the data (covering about 5 months). Figure 2 illustrates one of the two types of charts employed—the "standard sample" chart. Both this type and the "range" chart are employed by the laboratories:

(1) The standard sample control chart makes use of two simple graphs—one for a measure of the changes in level of results with time, the $\bar{X}$ plot, and a second for the measure of the spread of results, the R chart. The abcissa for both plots is time, the ordinate a quality characteristic; for refinery products it is normally a specification (sulfur content, flash point, viscosity, etc.). Figure 2 is a practical example of this type of chart. The test method in question had been in use for a number of years and was thought to be very reliable. As the data from blind and random submission of a standard sample began to show a stable level, but undesirable ranges (from 3/29 to 6/4/54), it was concluded that a change in technician was desirable; an examination of equipment and procedure was also instituted. The result of this short-term study by the foreman showed the equipment to be the important factor; in this case a change from a porcelain to a platinum crucible to carry out our ashing procedure was instituted. The out of control points No. 11 for ranges and No. 12 for levels were attributed to poor equipment and an unwise change in technicians respectively. With a change in equipment and the original technician, subsequent ranges (points 15-24) reflected an improvement in generally lower and more stable ranges; the level of results during this time reverted back to that reflected by points 1 through 6 (3/29 to 5/13/54). The above experience is illustrative of the typical results of employing the control chart technique. Examination of chart information normally reveals that for a period of one to three months a standard well-established test method seems to behave as expected; enough time must be allowed for all possible variables to exert their influence on the overall variability. The test method used in the example continued to reflect ranges higher than were originally thought to be normal before any control chart examination was undertaken. Currently, intensive analytical development is being carried out to replace the procedure with a modern instrumental technique.

TABLE II—Typical Reduction of Standard Deviation After Use of Control Charts

Test No.	Std. Dev. Reduced by a factor of
1	0.50
2	0.25
3	0.25
4	0.14
5	0.16
6	0.33
7	0.50
8	0.33
9	0.25
10	0.50
11	0.25

(2) The second type of chart, illustrated in Fig. 3 is a plot of ranges (R) only. This is used to monitor methods employed to analyze products which are not stable enough to keep on hand in the form of

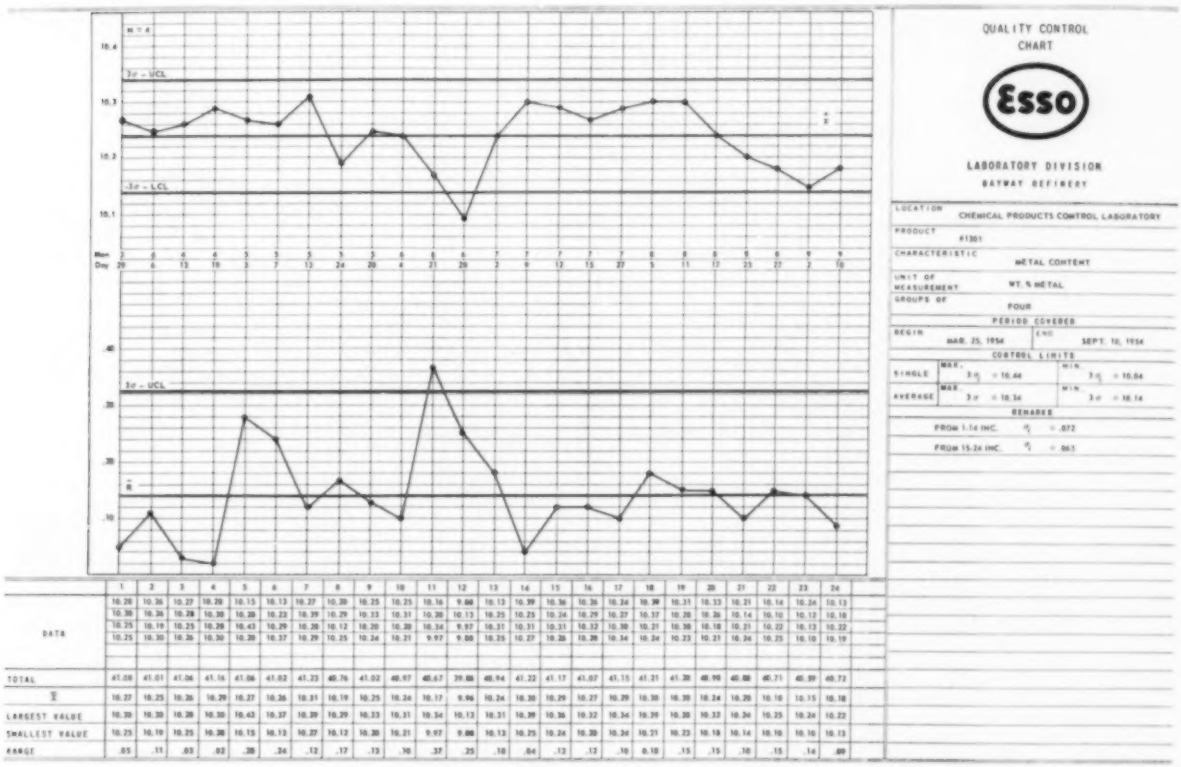


Figure 2—Standard Sample Quality Control Chart

standard samples. In the example (Fig. 3), a reduction in range (R) with time reflects an improvement in precision. Control limit lines were reset to conform to a lower average range toward the latter part of the time interval (2 months) covered by the chart.

Accomplishments

Over a two-year period, the quality control program described has made it possible to place 75-80 percent of the routine inspection work load in statistical control. This includes practically all specification quality evaluations carried out by the laboratories. It involves over 100 test methods, many of which have been improved and all of which have arrived at a state of "statistical control" (consistently reliable at a specified level of precision). It is emphasized that this was accomplished as a result of the efforts of laboratory technicians and foremen as a part of their daily work routine.

Table II lists typical improvements that have been experienced with about 90 percent of the test methods monitored for quality with laboratory control charts. Normally, a reduction to about one-half of the before-chart standard deviation is experienced; some of the tests improved to as much as one-fifth of the before-chart standard deviation.

The program has worked very successfully from the standpoint of calculated monetary returns due to improved test reliability. Perhaps a more important advantage, although intangible, has been a reaffirmed interest of laboratory personnel, foremen as well as technicians, in the significance and quality of their efforts.

Most test methods monitored with control charts arrive at stable level of precision. This condition represents the best practical level of precision that can be expected to result from routine use of control charts. It also represents a history which serves as a reliable starting point for technical analytical development effort, if the level of precision is still not satisfactory. Some

TABLE III—Decision Policy for Reporting Laboratory Inspection

Introduction

The procedure outlined below is designed to serve as a guide to laboratory foremen in making decisions concerning the question of whether or not to report a test result on a sample. Its purpose is to enable foremen to make this decision on a maximum of two samples.

Procedure

Case I: When current control chart data show test method employed to be in statistical control, report the result as is.

Case II: When current control chart data show test method employed to be out of control.

1. Re-test independently on same sample; if the difference between these two results is within maximum allowable error, report the average of the results; if the difference is greater than the maximum allowable error, *discontinue analysing routine samples until the method is known to be in control.*

2. If not enough of original sample is available for second analysis, request a second sample of sufficient size to make two determinations. If the difference between the first analysis of the second sample and the original result is within the maximum allowable error, report the average of these two results.

   If the difference between original result and first analysis of second sample is greater than the maximum allowable error, analyze the second sample a second time. If the difference between the two results on second sample is within the maximum allowable error, report the average of these results; if the difference is greater than the maximum allowable error, *discontinue analyzing routine samples until the method is known to be in control.*

Case III: When there is no control chart in service for the method employed.

1. When the test method employed is believed to be unreliable, obtain two independent test results on each sample. Report the average of these results.

   When the range (differences) between at least 15 duplicate tests exhibits statistical control, analyze samples only once and report that result.

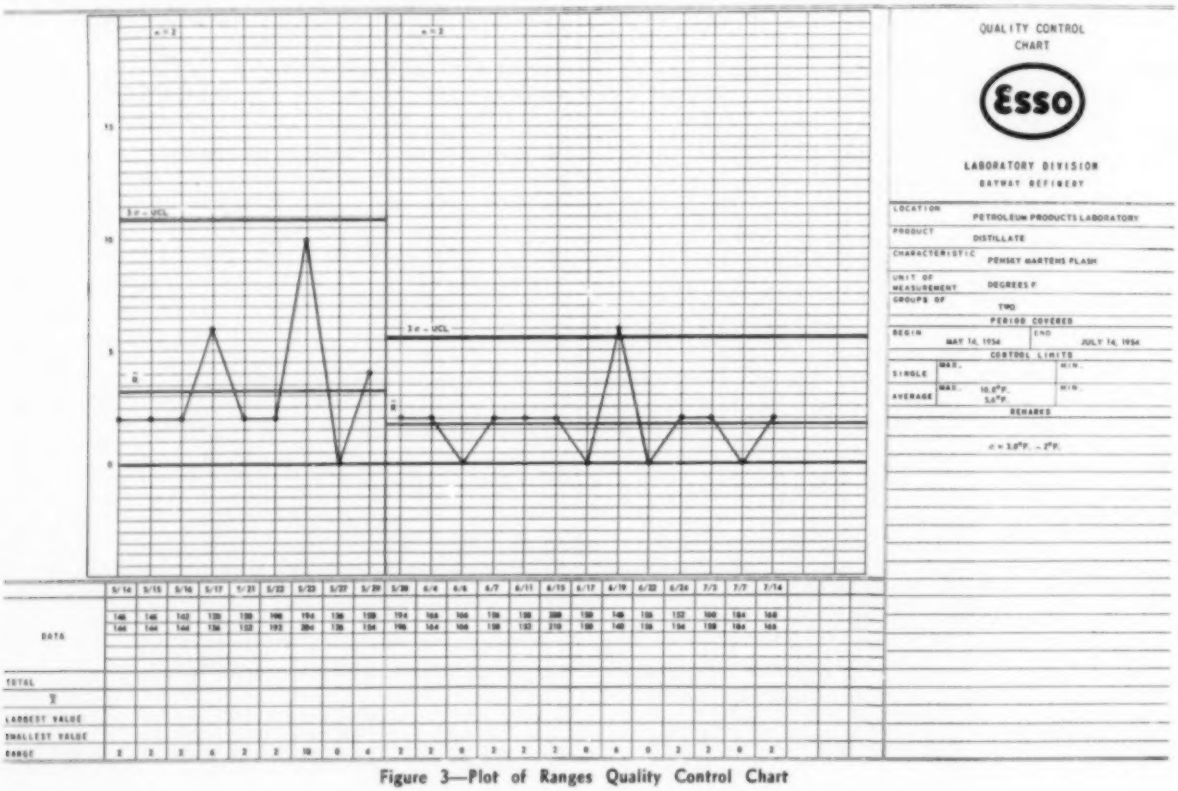


Figure 3—Plot of Ranges Quality Control Chart

tests show no improvement after a control chart has been in use for several months; it is our experience that such tests require a major change such as an entire new procedure, if improvement is economically justifiable.

These experiences clearly indicate that the control chart approach has accomplished two things: (1) it has afforded a very effective and inexpensive method of improving laboratory testing variability for many tests at one time and (2) it has served as a guide in deciding where concentrated analytical development effort should be applied. It is only after these two areas of activity have been exhausted that multi-testing is considered as a means of improving the reliability of results reported by the control laboratory.

Other Benefits

Among the many decisions a laboratory foreman must make every day is whether a sampled product is on or off specification; more generally, to decide what the quality level of the product is on the basis of a single test result. Daily decisions are made by these men whether to (a) report the original result, (b) request another sample, or (c) retest the same sample and report the first or second result or average these results. It is in this area that a strong statistical quality control program offers the foremen the "basis for decision" in their daily discussions with process personnel concerning the "true" quality of the product inspected. It offers him valid arguments to counteract coercion by process personnel to retest a sample when actually not warranted.

One of the benefits resulting from the use of control charts on test methods lies in the fact that practically every test so monitored soon exhibits "statistical control"; this is considered an improvement even though the data do not exhibit a reduction in standard deviation. Under these conditions, every single test result is the most probable candidate for the average product quality measure; in addition, definite statements can be made as to the maximum allowable difference between two independent test results on the same sample. It was with these considerations in mind that a "Decision—Function Policy" for laboratory foremen was formulated. Table III is a copy of the official policy. It is obvious that without reliable work-quality indexes (standard deviations) of test methods such a policy could not be formulated. It has been very well received by foremen, and has saved time and money in making decisions concerning intermediate as well as finished product quality. The enforcement of this policy has magnified the fact that the quality control function is a vital part of the laboratory foremen's responsibility.

TABLE IV—Sample Calculation of Dollar Savings Due to Reduction of Standard Deviations

Test Method:	Vapor Pressure
Std. Dev. before control chart:	1.0
Std. Dev. after control chart:	0.33
Unit Cost:	X DOLLARS*
Avg. No. tests run per day	13
Present cost to handle workload:	13X $/day
Cost of control chart analyses:	X $/day
Total cost of present system:	14X $/day
Cost of multi-testing: (9)† (13X)	117X $/day
Dollars/day saved:	103X

*Unit costs vary from 2 to 20 dollars.

†Number of tests required to be averaged to be equivalent to a reduction in standard deviation to 1/3 of the before-control-chart figure.

Economic Evaluation of Accomplishments

Multi-testing has been suggested as a means of improving routine testing variability, especially for those test methods which have a high economic value. The cost of such a program is defined as the number (N) of replicate tests that must be averaged to reduce the variability (standard deviation) of test methods to a desired level. The number of replicates that must be run is calculated as the square of the ratio of the current standard deviation to the desired standard deviation. This number (N) is calculated from the fundamental relationship.

$$\sigma' = \sigma_{\bar{x}} \sqrt{N}$$

$$N = \left(\frac{\sigma'}{\sigma_{\bar{x}}} \right)^2$$

Where

σ' = standard deviation of a single determination

$\sigma_{\bar{x}}$ = standard deviation of the average of N replicate determinations

On this basis, four replicate analyses must be performed and averaged to be equivalent to a reduction to one-half of the before-control-chart standard deviations; Table II illustrates the reduction of the before-chart standard deviations which resulted from the control chart approach. It is on this basis that the economic accomplishments of the program have been calculated. A sample calculation may be found in Table IV. Since a large number of tests have shown improvement similar to that illustrated in the example, the incentive to use statistical quality control runs in the thousands of dollars per day and into the million of dollars per year. Of course, it will be clear that a multi-testing program on a large scale would never have been undertaken. Nevertheless, the magnitude of the high cost of multi-testing compared to the use of control charts clearly illustrates the wisdom of going this route; in fact, any alternate route would present a prohibitive cost.

Summary

The quality control program described in this article has been a successful venture for two years.

The laboratory control chart has provided realistic measurement of prevailing testing variabilities for many standard well-established test methods. In many instances, specific and removable causes have been detected and eliminated or at least minimized after isolation and correction.

In addition, the quality control program has served to maintain levels of performance and ranges of variation.

Most important, the quality control system described has provided a continuous, representative check on overall laboratory performance, and therefore reflects management acceptance of its responsibility for maintaining standard and stable conditions. As a result, the huge inspection job of our refinery today is being run like an efficient business. The commodity we sell is data. Our aim is more reliable data for the customers we serve. Quality control has been an effective means for doing this job.

AUTOMATIC QUALITY CONTROL

Pipe Dream or Reality?

T. WILLIAMS ROBERTS, JR.

Fischer & Porter Company, Hatboro, Pennsylvania

Introduction

The amount of paper in the form of reports, budgets, schedules, and audits that passes over management's desk these days is staggering and yet the need for more data, reduced and summarized, on which to base a decision is uppermost in management's mind today.

The annual financial statement is no longer enough to permit executives to plot a realistic course, and monthly closings are needed to indicate company performance. The need to know "Are we operating profitably right now?" is constantly in our minds.

Business leaders for years have been evaluating their progress by charts and logs of company performance. Farther down the line, especially in production operations, process performance is evaluated on the basis of information gathered during the course of production. Factual data, reliable and on time, has become so much a part of our every day business functions that very few businessmen can make a decision without it.

So it is with process control.

About a year ago I saw a cartoon which described the growth of the quality engineer and at the same time poked fun at the growing monster called data processing.

Pictured as circa 1900 was the kitchen-like laboratory of the food processor with the cook bending over the pot sampling the soup. On the floor a baby labeled "quality" was playing with a small bucket of red and white marbles and a small contraption which I found out later was used by quality engineers to demonstrate distribution and probability.

The next picture marked 1925 showed the same disarranged kitchen with several control instruments mounted on the wall but the cook was still sampling the soup and disregarding the dials. The "quality" baby, now a young man, was pictured asking the boss for an elaborate control system which was shown as a vision up in the blue sky.

Then in the next picture labeled 1950 we saw that vision come true with a gigantic instrument panel and several quality investigators on roller skates taking data madly. Off in the corner was the quality engineer's desk piled high with data, log sheets, control charts, bell curves and the like, together with a corps of typists.

The final picture, marked circa 1960, showed a modest data processing system humming efficiently and several automatic typewriters preparing concise-looking log sheets. An attractive girl was watching the system and cans of soup stamped "OK" were flowing out the door. The manager of quality control was sitting in a plush office and the president was handing him a check marked "bonus."

If I correctly interpret the cartoonist's message, there is "plus" money available in controlling not only the process, but also the data.

The Quality Control Program and Data Reduction

There has been a recent marriage between the control instrument and the computer resulting in a new concept of process control called "Automatic Data Logging." I think we all identify the quality control organization as management's tool for maintaining product quality. It is with product quality, through process control and data reduction, that the material in this article is concerned.

We have heard a great deal of static in recent years about computer control and the panacea it will provide, yet a complete control loop would show that the flow of materials is constantly influenced by management decisions such as rate of production, rate of sales, supply, demand, but far more abruptly by subsidiary controls which are exercised at many intermediate stages of production. Assuming that the loop consists of a controlled, or at least a controllable process, the objective in setting up the operation is, of course, the profitable production of goods of sufficiently high quality to assure complete customer satisfaction.

This objective is generally reached in two steps: first, attaining the desired quality level requires gathering and digesting large amounts of data to establish the relation between the output, the control settings and the inputs; secondly, we establish and police the operating procedures that will perpetuate a profitable quality level. Once established the effort may be throttled back but not discontinued, for experience has taught us that maintaining a quality level means continuously proving test procedures and operating techniques. The cook, you will remember, was always able to taste the soup and add a pinch of salt.

There is usually an abundance of collected data associated with manufacturing operations. Quite often, though, the form in which it is stored, and the accuracy with which it is taken, adversely prejudice further use. Furthermore, in continuous fluid processes data are lost during upset conditions since operating personnel are rightly more concerned with corrective action than jotting down indicator readings. Here then are two very valid reasons for automatic data handling.

Generally speaking, American industries, largely through the influence of quality minded management, are willing and anxious to collect data. Summarized control data is essential to many operating departments; for instance, the accounting department wants data to plot efficiency and monitor cost centers. Where analytical methods are being developed or where efforts to develop statistical design approaches are being considered, the

engineering department will also want data. But most important, production, in the person of the quality engineer, uses much of the data to determine yields or investigate reasons for the lack thereof.

In discussing material for this article with quality managers I was impressed by the feeling that a quality assurance program capable of forewarning of possible process failure needs a history of continuous, reliable control charts, and the troublesome interpreting of graphic analog data makes forecasting rather risky.

Apparently the most useful tool to the process quality engineer is digital data gathered from a number of points simultaneously at a given instant in time. The elaborate process control panels described in the cartoon are not capable of developing this kind of data and the demand naturally led to the development of the digital data logger.

The field of industrial data reduction concerns itself with a problem of measuring large numbers of physical variables and reducing or displaying this information in its most usable form. The most usable forms are typewritten log sheets, punched tape, and punched cards.

The typewritten log sheet is most popular particularly when certain computations such as yield, average flow, trends, standard deviation, and auctioneering are logged along with control values. Portions of this typewritten log sheet can be routed to departments awaiting their particular operating data. Punched cards likewise tie in with IBM accounting systems.

Applications of Data Logging

We will discuss a little later some specific industrial data collection systems but suppose for the moment we examine several of the situations in which data reduction equipment is proving most valuable.

In the continuous process industries, whether fluid or mechanical, applications of logging or data reduction are not being confined principally to the recording and tabulation of production variables but, in addition, include the computation of secondary variables known as operating guides. These continuously computed operating guides provide a single number which effectively indicates the quality of the output. This single number, which is a yardstick or scale of value, can be yield, average heat rate, thrust per pound of fuel, material balance, but more than anything else represents the common denominator of process performance; namely, money. The industrial process logger can be made to look at over-all plant performance even though it is a function of numerous variables in the flow stream. In mechanical operations it is often essential to know who goofed, how much and where—and this is represented by a departure from preset limits and a discrete count showing how many and how often. The automatic data logger differs from conventional process control by permitting us to take an instantaneous photograph of what is going on within the process and simultaneously comparing this performance with preset high and low limits.

Aircraft Industry

The aircraft industry is concerned with the manufacture of a very complex product in which large amounts of time and effort are concerned with the evaluation of the performance of the final product. Data reduction equipment for flight testing involves some of the most advanced telemetering techniques now available including ground base equipment for the receiving of telemetered data.

The reduction of these data to digital form, followed by computation or analytical procedures carried out automatically, reduces the mass of data printed out to a form suitable for immediate interpretation.

In ground testing of aircraft equipment, data processing facilities provide means of simulating many of the conditions experienced during flight, and recording them. In such applications automatic data processing equipment provides savings which annually amount to several times the cost of the equipment itself.

Petro-Chemical Industry

In the petro-chemical field, current techniques include continuously measuring at high speed such variables as temperature, pressure and flow, periodically totalizing accumulated flows to date and programming these data in logical form on a prepared log sheet. Included also in equipment for this application is the ability to correct automatically for temperature and pressure variations—and even specific gravity—in order that the final recorded value will be in a form suitable for immediate use particularly in accounting procedures.

There seems to be no end to the ingenious transducers being developed for converting variables to signals suitable for digitizing and recording. Someone told me just recently that the French have an electro-chemical device for determining sex prior to birth.

Uncontrolled Variables

Another area in which data reduction has proven its value is in the monitoring or alarm scanning of uncontrolled quantities in a manufacturing operation. By uncontrolled we are referring to quantities which can be manually corrected but are not under the direct and continuous control of automatic equipment. Examples of such quantities are the bearing temperatures of rotating machines, temperatures at extrusion nozzles in the manufacture of yarns and fibres, and in a number of other purely mechanical applications.

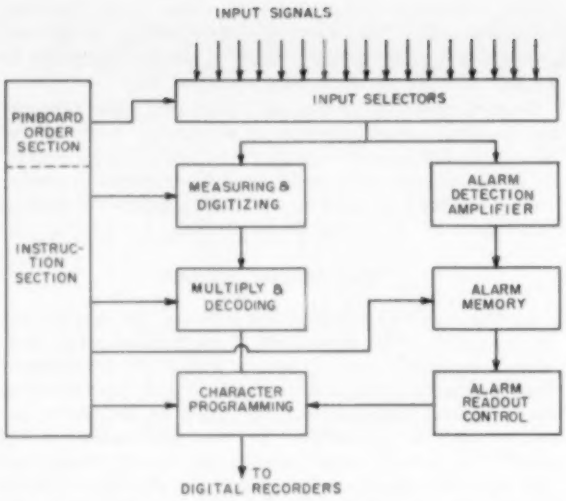
The Quality Manager and the Process Plant

For the purposes of this article a process plant may vary from aircraft in combat, a chemical processing unit, the various power plants of an electric utility, a pipeline for the delivery of gas or fluids, or a manufacturing plant producing discrete mechanical products, each of which has its own quality value. Essentially the process plant is the element over which supervision and control are exercised and which is subject to the various disturbances present in its environment.

The purpose of control is to perform a supervisory function; specifically, to counteract the influences of various disturbances and effectively to force the process plant to conform to specified conditions which generally are in the form of control set points. This becomes in effect the legal obligation of the quality manager. The operating procedure is the legal document which describes the process and the limits within which the process will produce a high yield.

The tool for policing as well as enforcing this law can be process control in the form of data reduction. The quality manager, instrumental in coordinating back data with current experience, is perhaps in the best position to utilize the biasing or coordination feature that can be provided through the use of computer techniques auxiliary to the data logger.

The coordination element is sometimes overlooked in over-all process operations, but actually it acts in the



Block Diagram of a Typical Automatic Data Processing System

capacity of a memory to store all of the known information about the process. In addition to this storage function the coordination element interprets any command in the light of the stored knowledge and can specify the values of set points through the control elements which then execute the desired pattern of coordination on the process.

In military gunfire the coordination element appears as a continuous computer which stores within it the various mathematical relationships involved in pointing the missile and finding the target. In the operation of the continuous fluid process the coordination element may be the background or past experience in the operation of the process, taking into consideration atmospheric or environmental effects.

Thus, with the current method of combining process control instruments, data reduction and computers, we have an opportunity to equip the process with a memory and provide it with a coordination element that in the past existed only in the person of production operators or deep in the files. This ability, when it existed in the mind of a skillful process operator, was something akin to witchcraft. It is essentially the cook sampling the soup, and it is interesting to think back and contemplate why the cook continued to depend on taste rather than the dials.

Operators in every industry are still adding a pinch of salt now and then because the dials in the control room don't quite tell the whole story. I think it has been evident in recent years that current quality control philosophy involving forecasting or long-range production plans includes this memory or witchcraft in the selection of seasonal guides and trends in the correlation of last year's experience with this year's data.

Test Cell Loggers

Considering now the specific application of loggers in various actual installations, first let us look at facilities devoted entirely to the generation of data. Foremost in this category is the military aircraft industry, particularly engine test cell facilities.

In production test cells where each engine is given a shakedown, there are perhaps sixty variables to be measured each minute with accuracies on the order of ¼ of 1 percent.

In development test cells where new engines are being developed and evaluated, the many uncertainties in the development engine sometimes require that two hundred or three hundred data points be logged with accuracy requirements better than one-tenth of 1 percent. The manual logging of sixty data points per minute requires as many as six men as opposed to a single operator for an automatic data logger.

The logging period may extend over a twenty-four hour period requiring extended shifts to complete the data record. In addition to the manpower cost, one must consider the fatigue which these men endure. Certainly the validity of their performance after six to eight continuous hours is open to question.

The automatic data logger will prepare an organized record of all variables, minute by minute, tabulating true instantaneous values. Furthermore memory lapses and personality conflicts are not among the variables. Temperature signals from thermocouples, pressures as pneumatic signals, flows, speed, torque, weight, thrust, vibration, and other miscellaneous signals which are available from a wide variety of primary instruments are measured and printed as true values.

These data are logged simultaneously which is not possible through manual logging and results in a photograph of engine performance at a given instant in time.

Abnormal conditions—namely, failure of the variable to fall within present limits—are indicated on the log sheet by means of a print-out in red. A test cell operator therefore is not only able to operate from an easily read digital display but is also warned of upsets and stall conditions which are clearly designated in red. Development test cells require more flexible and certainly much more accurate measurements. The data collected by such test cell loggers as these frequently form the basis for complete engine redesign or for re-evaluation of a production technique.

Whatever the end use of the data, the task of compiling, interpreting, and transcribing for insertion into computers is significantly simplified.

An unusual application of control coordinated with data reduction will be taking place at the site where the Nautilus' power plant was first designed. There will be a simulated submarine control room used to train Naval personnel for duty aboard future atomic submarines. Data loggers will be used to record the reactor variables including nuclear power output as trainees put the sub through its paces. This not only serves as a monitoring and alarm system but provides a digital record of the capabilities of the crew.

Loggers For Continuous Processes

Automatic data loggers for use with continuous processes are faced with an entirely different problem since such a facility exists for the purpose of profitably producing a salable material. Data in a continuous manufacturing process are often only partially utilized because summarizing and computations come too late to be useful.

To fulfill operating requirements for data loggers for industrial use the logger must perform many functions in addition to measuring and digitizing.

For example, instantaneous flow signals may be corrected for process pressure and temperature, or variations in specific gravity of the material in transit. Furthermore, mechanical signals from transducers converting physical dimensions to electrical equivalents must be integrated or root squares extracted on demand or at pre-set intervals.

Essentially the industrial logger is involved not only in process control and data reduction but also arithmetic computation. In contrast to instantaneous values of temperature, pressure, flow, heat rate or the like which are suitable for alarming abnormal conditions and correlating product variations with process instability, computed points provide immediately useful operating guides.

In addition to averaging, a new technique known as "auctioneering" is available which selects the highest or lowest value from a series of readings.

Fuel heat content, flame temperature, changes in furnace efficiency can be computed and logged. Catalyst circulation rates, carbon burning rates which are operating guides familiar to refining men, are calculated in a logger computer and it is interesting to know that some of these guides are so awkward to compute manually that it has been customary to compute them once a day and apply any corrections thus developed to controls at that time. By automatic means this computation is made hourly and could be made continuously if that were desirable.

One of the first successful data loggers to be installed has been in continuous use for almost two years in a catalytic cracking plant. This installation proved two things: First, that reliability can be built into a digital data system, and secondly, that operation of a process from a central point where process variables are organized and recorded in digital fashion is conducive to product control.

It also brought out the fact that very often variables which are manually logged religiously have absolutely no use in the control of the process.

Detecting and Alarming Abnormal Conditions

The detection of abnormalities may be freed from the restriction imposed by periodic logging by continuous scanning techniques.

Alarm scanning devices sequence the various inputs to the logger through an alarm detection circuit where the signals may be compared against high or low set points. These scanners operate at rates between five and ten points per second. Thus, for example, one hundred variables may be compared with individually adjusted high and low set points in ten to twenty seconds.

On detecting an abnormality, it is possible to cause a full readout of all data points being fed into the logger with those points that are abnormal being typed in red, or an alarm log sheet can be prepared on a separate typewriter quite distinct from the normal log sheet. On this alarm log sheet the time of detection, the identification of the abnormal point, and the value of those variables which are abnormal will be typed in red.

Upon a return to normal from any point which had been outside the allowable limits we get a print-out of time again, the point identification, and the value of the variables that have returned to normal printed in black. Thus by scanning the log sheet it is possible to detect which points are abnormal, which are returned to normal, and the time during which the abnormality existed.

Of particular interest to quality engineers who are involved in the start-up of a pilot operation or a new process where many uncertainties are bound to occur is a mode of operation known as *digital trend recording.*

Digital trend recording gives the operator of a data system a greater flexibility than can be found in an analog control system. Where a logger is provided with this feature the operator may select various inputs to a system and present them in any convenient order on part of the alarm log sheet. The points selected for digital trend recording will be typed out at one point per second continuously. Thus if twenty points were to be selected at any one time, a full trend readout would require twenty seconds.

Successive entries of a particular variable as logged in this section differ in time by no more than twenty seconds. The values of these particular variables are typed in uniform columns making it easier for the quality engineer to scan the column and watch the trend.

Automatic Control

The processing of photographic film poses some rather stringent quality problems and a photographic film manufacturer recently purchased a logger to be used in connection with the automatic production of light sensitive film. This logger comes within one step of completely automatic control and automatic programming of a process.

Prior to start-up of the process a demand log is initiated which shows the set points of the various controllers as read from a previously prepared punched tape. A second log follows immediately showing the actual setting of the controllers involved. Thus before the process begins a complete check of the setup is immediately available. A third log of a number of points which are not controlled but which may affect the operation of this process is then read out.

After this third log has shown that set points are properly set up and that other critical variables are in line, no further read-outs are made until an alarm condition is indicated by the action of a control device.

When a process upset occurs the following information will be printed out on the log sheet: First, the time to the nearest minute; next, the number of feet of product that had been prepared up until that time, then a symbol printed in red will identify the nature of the alarm—that is to say, whether it be temperature, pressure, dimension, or some other variable. Then all other variables within that particular group will be typed out, the abnormal point clearly shown in red.

This process falls short of being completely automated by requiring the visual correlation of original set points, as fed in from a master program tape, and the actual controller setting that is read from the process itself. The technology for making this process completely automatic has been developed and the decision to take this next step will be determined on an economic rather than a technical basis.

The glass and ceramic industry likewise provides an interesting application for a digital control chart showing the temperature gradient through the length of a long kiln. It is customary for a quality monitor to extract data from graphic instrument charts and plot as many as 50 points to build a curve showing the profile of the kiln temperatures. The value of any one point is somewhat less important than its relation to its neighbors since the rate of heating and cooling tend to determine the quality of the product.

The difficulty with many systems is that there is a time lag between detecting a drift in the curve and making a correction. As a result, it is possible to make a reset some time after the condition has righted itself or even reversed. This lag time is being minimized by one of the larger glass makers with a data logger that displays the 50 temperatures on a single typewritten line. This digital array is horizontal across the log sheet.

Readouts can occur as frequently as one a minute. With such a digital display the quality engineer not only

can relate the temperatures one with another but can spot trends throughout the day. The log sheet then becomes a concise history of each batch. Savings are considerable since less expensive controllers take the place of strip chart recorders resulting in reduced maintenance and lowered initial capital outlay.

Automatic Quality Control

The quality engineer's function in a controlled process is guiding management in production decisions which will result in high yields and high quality products. From time to time this function of decision is based on information obtained from beyond or outside of the process plant itself such as information which relates to the environment or climate surrounding the process.

Frequently the purpose of this decision is to specify whether or not the process shall be operated at all, and if so, how. There are processes, such as electric utilities, in which the decision function is carried out by systems of equipment and relates to the measure of the energy balance existing on the system—a function of the supply of power to the demand for power. Not many manufacturing processes are influenced by so fundamental a relationship, however, and information required to maintain the process is much less stable and contains far more subtleties.

How then can we set up automatic continuous process quality control? Indulging in a little pipe-smoking on the subject of automation we see the need for a means whereby we might isolate various problems that arise, and bring to each problem the particular skills and experience most likely to solve it. This objective has not been served adequately and we have only to review the current literature on the subject of automation and process control to prove it.

From a reading of the literature it is evident that engineering effort is centered around the analysis and application of closed loop control systems. Under the circumstances it is small wonder that the prevailing cry is "too little is known about process dynamics to automate the process."

There is an alternate.

The customary statistical approaches used by the engineer and which have become so important in forecasting process performance can be very effectively applied through a control system built around an automatic data logger and computer. Considering the fact that every operating process is automated to one degree or another, quality functions and the elements of control are certainly being carried out at least to a satisfactory degree. On this basis, then, the goals of continuous automation are not to solve new and unfamiliar problems but to obtain improvements in functions that are already being accomplished.

Automatic quality control is then within reach since automatic sampling, frequency distributions, digital control charts, and computer functions to develop sigmas are available in today's market as elements of a data reduction system. If we accept the concept that a process which is automated to maximum economic degree is a process which is studied by a team of quality engineering personnel for the specific purpose of adapting today's knowledge to the process problems at hand, then the cartoonist had the right idea a year ago. He indicated that by now we would have a system not only grinding out sensible data but stamping "OK" on lines of soup cans flowing out the door. And—the business man with his staggering flow of paper work may very well find relief.

Acceptance Plan for Automotive Vehicles

B. L. HANSEN

*National Institute of Managment, Cleveland, Ohio**

MOST readers probably are well aware of the consumer-vendor relationship between the Department of Defense and its suppliers. This relationship differs somewhat, depending upon the particular department buying the material; however, the departments are alike in one respect—each demands some measure of assurance of quality. In the Ordnance Department, quality may be assured in many ways, ranging from quality level certification at one extreme to 100 percent Ordnance inspection at the other, and with varying degrees of standard and non-standard sampling in between. However, the Department is always on the alert for logical ways of reducing the incidence of both 100 percent and non-standard acceptance inspection.

Specifically, this article is concerned with the adaptation of MIL-STD-105A to the acceptance inspection of the M38A1 truck, commonly called "the jeep," manufactured by Willy's Motors, Inc., in Toledo, Ohio. Willy's Motors, now Kaiser-Willys, is situated geographically within the Cleveland Ordnance District. This District has been procuring and inspecting jeeps since pre-World War II. Until November 1952, the inspection phase of this procurement consisted of inspecting each and every jeep purchased. As each jeep came

*At the time information for this article was gathered, Mr. Hansen was employed by the Cleveland Ordnance District.

off the production line it received a so-called 100 percent inspection check in which there was no meaningful differentiation made between serious and non-serious defects. A check sheet was completed for each jeep inspected; defects were corrected by the contractor; and the check sheets were filed away. During November 1952, a standard sampling acceptance inspection plan was put into effect. This plan, with slight alterations, was still in use at the time the author terminated employment with the Cleveland Ordnance District in 1955.

Needless to say, there were obstacles to overcome in introducing the sampling plan to the contractor, not the least of which was the contractor's fear of lot rejection. Considering the type and cost of this item, and that this would be the first application of acceptance sampling to a complete automotive vehicle, his fear was not incomprehensible. However, this and other obstacles were arbitrated and the plan was put into effect.

Table I shows a list of possible defects on the jeep which were classified into special, major, minor, and incidental defects. The classifications are defined as follows:

Special Defects: Those defects which might endanger using personnel, cause adverse results in combat, and/or indicate a serious breakdown in production control. At the option of the resident inspector of Ordnance, any characteristic may be added temporarily to this classification in order to assist the contractor to regain control in process.

Major Defects: Those defects likely to result in the failure of the vehicle to function as intended, but not in danger to personnel or in the loss of a tactical engagement.

Minor Defects: Those defects likely to cause the vehicle to function with reduced effectiveness or to interfere with subsequent assembly or repair.

Incidental Defects: Defects which are deviations from good workmanship and which have no effect on function, assembly, repair, or life of the vehicle.

Major, minor, and incidental defects are sampled in accordance with the normal single-sampling table in MIL-STD-105A. Special defects, due to their nature, receive 100 percent inspection. One might find some fault with the leveling effect of the classification; for example, it makes all loose bolts equally serious, no matter where they may occur. However, at the initial stage of planning the big job was to get the defects classified so that all concerned would use the same frame of reference in regard to the seriousness of a defect. Maybe these small inconsistencies would have little effect on the primary aim of improving quality! At any rate a trial period would serve to do much to answer any uncertainties. The acceptable quality levels for each classification were additional points for arbitration and the final acceptable quality levels, (AQL's) of 15, 150, and 400 for majors, minors, and incidentals respectively, were established by approximating the then current percentage of defects for each classification. This is not the standard method of assigning AQL's, but was a selling point.

November 11 to December 16, 1952, served as a trial period during which there were a total of 5,280 vehicles accepted. These vehicles were submitted to Ordnance inspectors in lots of 60 each. From each lot a sample of ten was selected at random. A total of 88 lots were inspected of which none were rejected for majors and 2 and 4 were rejected for minor and incidental defects, respectively. However, and this was another selling point, the contractor did not have to make repairs on vehicles in accepted lots other than those turned up in the sample inspection. As a result of this trial period, some minor adjustments were made and the plan was considered adequate for future acceptance control. Subsequently, the contractor was able to reduce the size of his repair personnel staff which resulted in renegotiation of the contract at less cost to the government. This renegotiation plus the reduction of 19 Ordnance inspectors resulted in a direct savings of $500,000 a year

Table I—Acceptable Quality Levels and Classification of Defects for Automotive Final Inspection and Road Test

SPECIAL DEFECTS—100 percent inspection of vehicles for special defects will be made. Any occurrence of these defects on any vehicle of the lot found prior to acceptance, will require repair or replacement of the defective item by the contractor. This inspection will be made on every vehicle and will be the final operation on each lot of vehicles before final acceptance or rejection is made.

SPECIAL DEFECTS—0 DEF/100 Vehicles

A—Fuel leaks–drips
B—Coolant leaks–drips
C—Lubrication leaks–drips
D—Brake fluid leaks–any
E—Coolant level (use gage)
F—Any apparent serious malfunctions or damaged part
G—Foot brake inoperative
H—Steering mechanism loose or binding
I—Shortages
J—Winches–Fording equipment and other special items (any defect)
K—On vehicle items (O.V.M.)—Missing, damaged, or improperly mounted

MAJOR DEFECTS—15 DEF/100 Vehicles

1. Steering wheel knuckles and linkage—loose or excessive play.
2. No shift or unusual noise in power train.
3. Excessive vibration.
4. Clutch—slips, drags or chatters.
5. Oil pressure—low or gage inoperative.
6. Engine heat—high or gage inoperative.
7. Brake, foot—grab, chatter or unequal pull.
8. Excessive heating—all units in power train.
9. Lights—complete circuit inoperative.
10. Glass, windshield—fogged, cracked or broken.
11. Wipers, windshield—inoperative.
12. Vacuum test—engine.
13. Fuel tank—not strapped securely.
14. Pintle hook—inoperative or improperly mounted.

MINOR DEFECTS—150 DEF/100 Vehicles

51. Pedal or linkage adjustment required—Brakes, Clutch, Accelerator.
52. Fuel pump—improper mounting or assembly, damaged.
53. Instruments inaccurate—ammeter, fuel, speedometer, others.
54. Unusual engine noise.
55. Engine tune-up required.
56. Improper lubrication level—engine, transmission, etc.
57. Burned out light bulbs.
58. Horn inoperative.
59. Crank shaft pulley—wobble or misaligned.
60. Frame, springs, shock absorbers—improper mounting, cracks, welds, leaks.
61. Batteries, cables, acid level—defective or improper otherwise.
62. Wiring and tubing—defective or improperly mounted.
63. Water pump and fan assembly, blades, belts—improper alignment or otherwise defective.
64. Generator and starting motor—defective mounting or alignment.
65. Distributor—improper wiring—damage (including spark plugs, filters and voltage regulators).
66. Cylinder head and attaching parts—damaged, improper mounting (includes carburetor and oil filter).
67. Power train and power take-off—improper mounting or assembly, damaged.
68. Radiator—improper mounting or assembly, damaged.
69. Master cylinder—improper mounting or assembly, damaged.

INCIDENTAL DEFECTS—400 DEF/100 Vehicles

101. Body and hood items mounted thereon—improper fits, assembly welds, seals.
102. Sheet metal defects.
103. Paint defects.
104. Trim defects.
105. Lifting shackles—improper mounting.
106. Wheels and tires—improper mounting or assembly, damaged.
107. Controls and switches—improper mounting, clearance or condition.
108. Decals and instruction plates—improper position or condition.
109. Manifolds, exhaust system, air cleaners, crankcase breather—assembly or damaged.
110. Bolts, nuts, washers, clips, brackets, guards, clamps, vents, grommets, straps, buckles, locks, hooks, chains, wiper blades, horn button, lube fittings, and plugs—missing, insecure, off location, damaged.

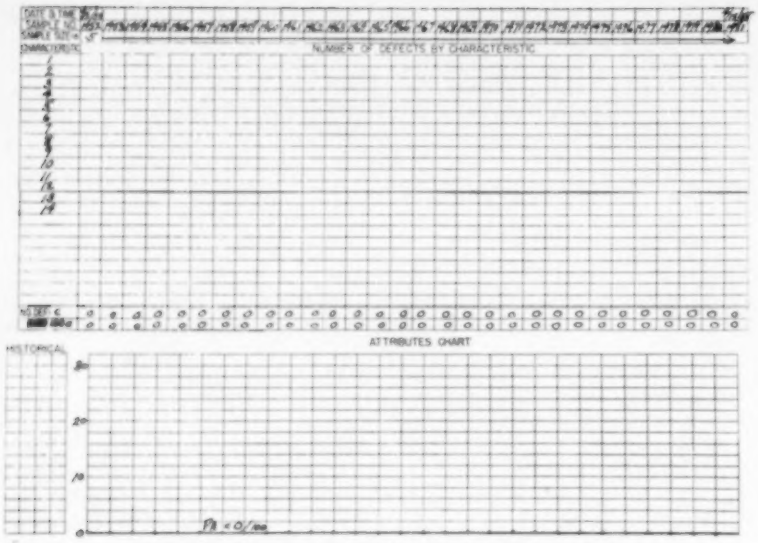


Chart 1—Data Sheet and Control Chart for Major Defects

predicated on current production. Even though production was cut back several months later and has been at a relatively low level since, the savings were still substantial.

Several representative charts have been selected to show the method of recording and reporting defects.

Chart 1 is a "u" chart for major defects. The symbol "u" refers to the average number of defects per sample unit and equals c/n, where c = number of defects and n = sample size. The ratio is expressed as 100 units on the chart. During this period, we were selecting samples of five from lots of 25 each. As can be seen, the process average for major defects for the period 4/1/55 thru 4 15/55 is 0 per 100 units. Each plot represents the results of inspection of one sample from one lot. The ration per hundred units was used because the AQL's in MIL-STD-105A are expressed either as percentage defective or defects per *hundred* units. Of course, the common denominator is 100 irrespective of which way we wish to express nonconformance.

Chart 2 is a "u" chart for minor defects for the same period. Note that the period for process average computation is arbitrary and that each period consists of half a month. If we were using the "u" chart as a process control, this would not be correct or sensible. Instead, for our purpose it served to alert the contractor to trouble spots and proved a convenient method for the systematic semi-monthly reporting of deficiencies to higher headquarters. The contractor should and did maintain

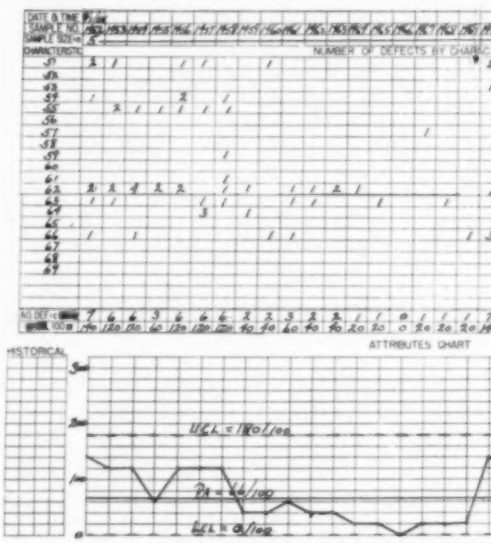


Chart 2—Data Sheet and Control Chart for

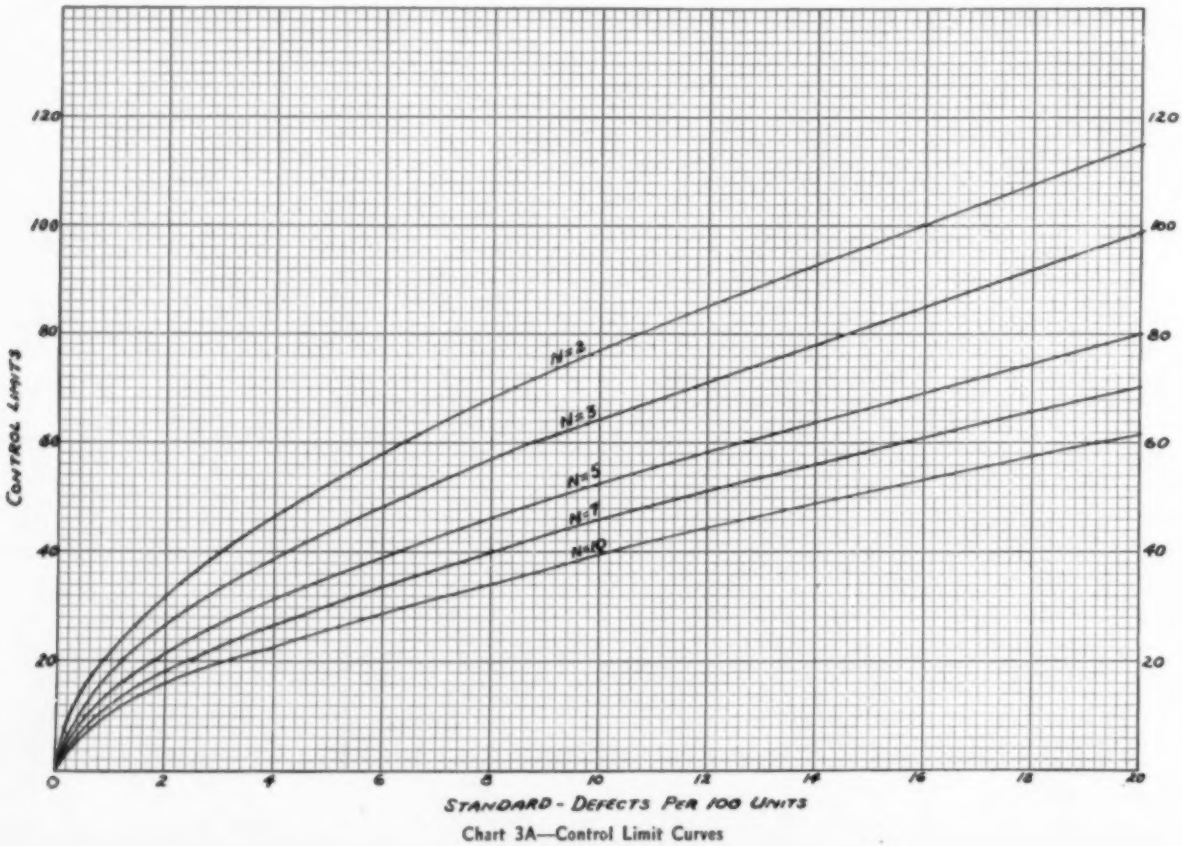


Chart 3A—Control Limit Curves

a "u" chart of his own. An unusual feature of the chart is the lower portion which points up the particular defects that are causing the most trouble. For instance, defect No. 62 ("Wiring and tubing defective or improperly mounted") is occurring most frequently. The process average for the first semi-monthly period in April is 66 per hundred units. The upper control limit is 180. The computation to obtain the process average and control limits is conventional and for those who are interested, an example follows.

rt for Minor Defects

Inspection for minor defects during the period 4/1/55 thru 4/15/55 showed a total of 99 defects in 150 vehicles inspected. The preliminary process average in defects per unit is $\Sigma c/\Sigma n = 99/150 = 0.66$, or to conform to MIL-STD-105A, 66 per hundred units.

MIL-STD-105A allows abnormal lots to be excluded for assignable cause,

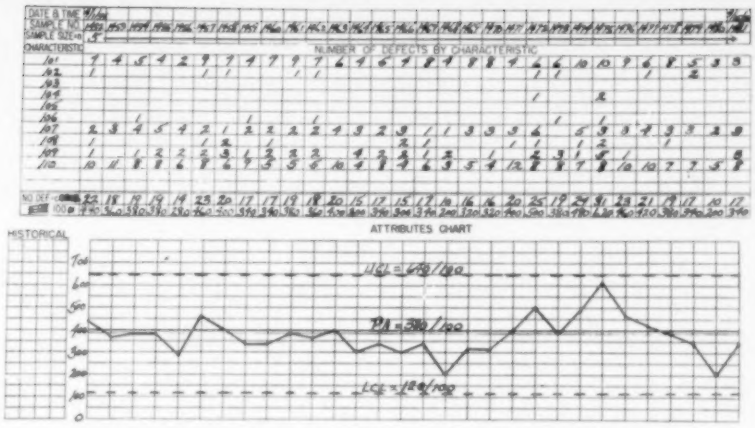


Chart 4—Data Sheet and Control Chart for Incidental Defects

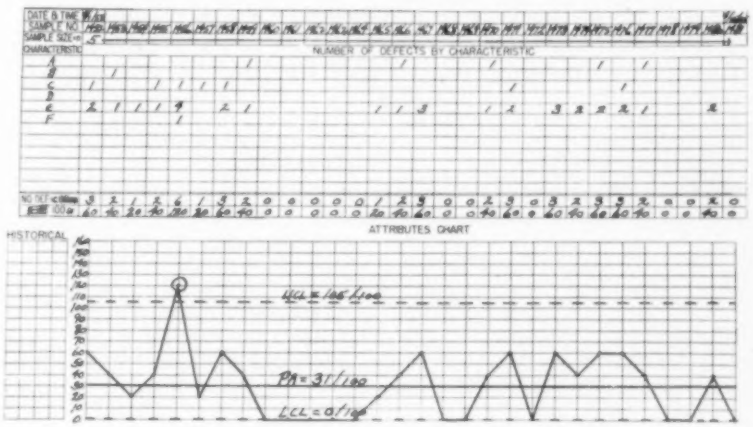


Chart 5—Data Sheet and Control Chart for Special Defects

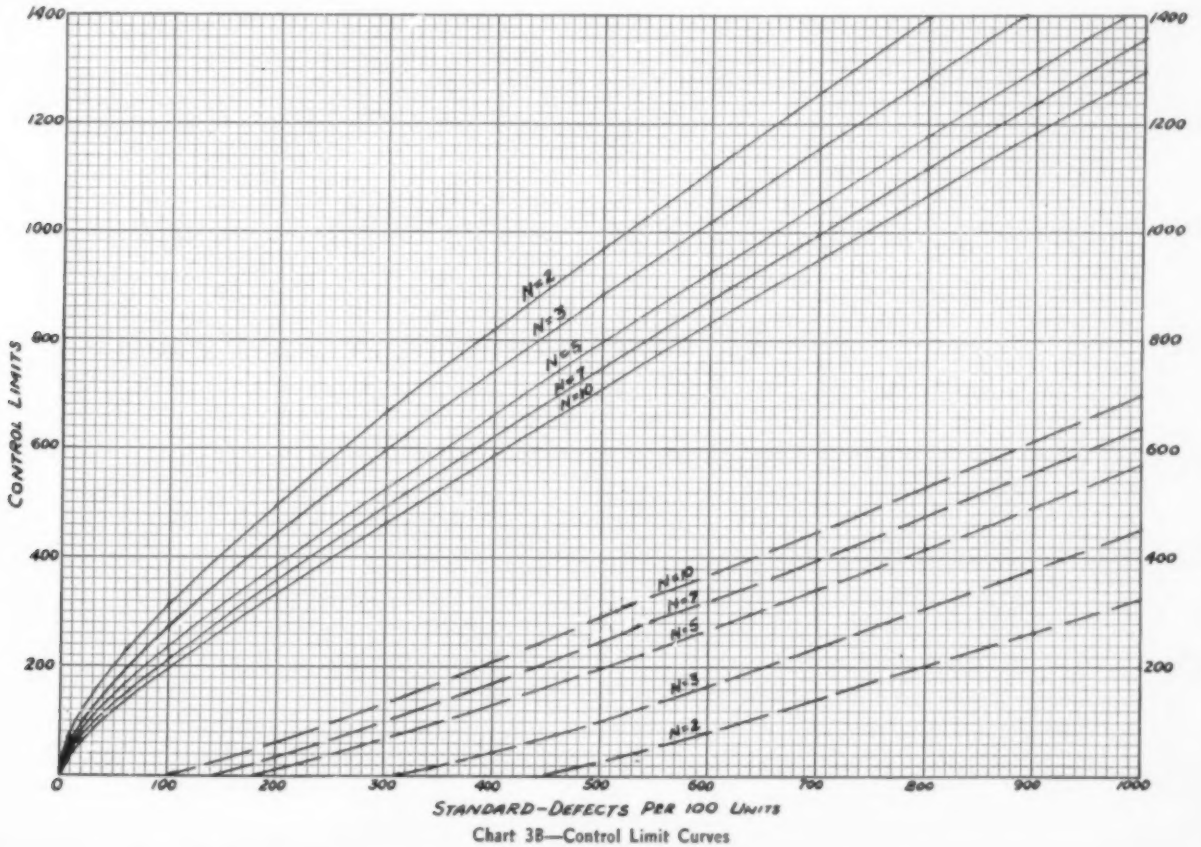


Chart 3B—Control Limit Curves

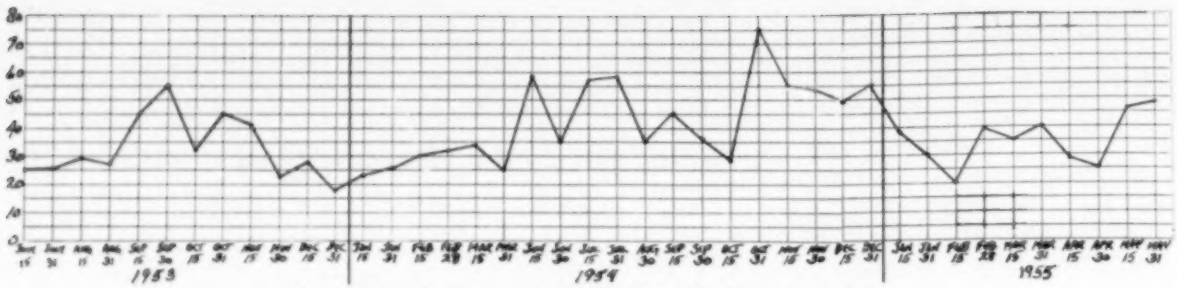


Chart 6—Quality History for Special Defects—100 Percent Inspection

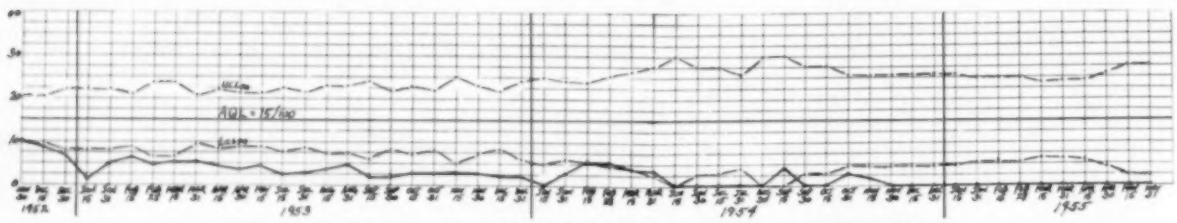


Chart 7—Quality History for Major Defects—(AQL = 15 Defects Per 100 Units)

so the next procedure is to compute conventional control limits for this preliminary process average.

$$UCL_{100u} = \left[\bar{u} + 3 \frac{\sqrt{\bar{u}}}{\sqrt{\bar{n}}} \right] 100$$

$$= \left[0.66 + 3 \frac{\sqrt{0.66}}{\sqrt{5}} \right] 100$$

$$= 175/100$$

$$LCL_{100u} = 0$$

No points are out of control so the preliminary process average becomes the final process average.

In order to reduce computational errors and minimize computations, control limit curves were computed for "n" values of 2, 3, 5, 7, and 10. It was not likely that we would be dealing with sample sizes larger than ten. The control limit curves are contained on Charts 3A and 3B.

For this example, reference to the $n = 5$ curve gives a value in the region of 180 which is close enough for practical purposes.

Chart 4 is a "u" chart for incidental defects for the same period. A relaxation of contractor control is indicated in lots 1471 thru 1477.

Even though special defects are inspected 100 percent, a process average "u" chart (see Chart 5) was maintained for the standard special characteristics to see whether improvement would be forthcoming without the stimulus of an AQL.

Chart 6 gives the complete story of special defects from July 53 through May 55. Each plot represents the final process average for a semi-monthly period. It is evident by comparing the special defect history (which shows no improvement over a long period of time) to the history for major defects on Chart 7, that the placing of an AQL on a defect classification has the beneficial effect of giving the contractor a nominal value to shoot at and which he takes justifiable pride in bettering. As can be seen, the quality of major defects improved steadily from an average of ten in November 1953 to zero in November 1954. The zero has held through May of 1955 and longer.

Chart 8 depicts the same type of history for minor defects. Initially

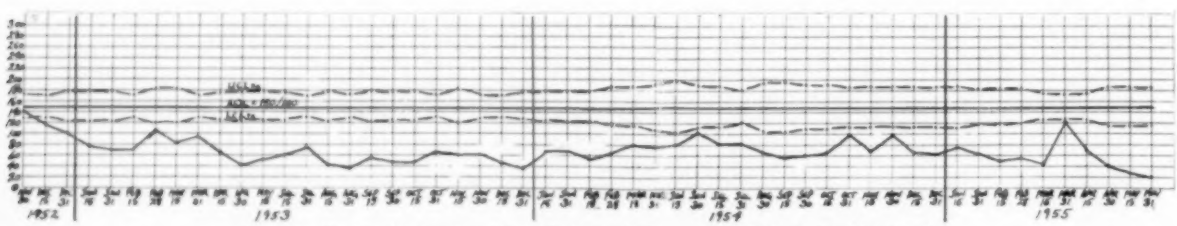


Chart 8—Quality History for Minor Defects—(AQL = 150 Defects Per 100 Units)

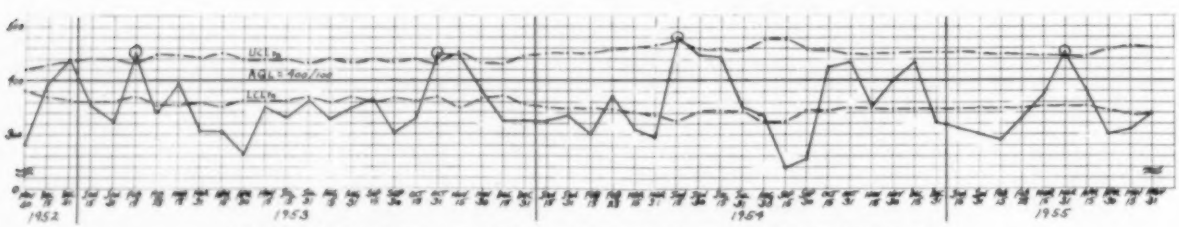


Chart 9—Quality History for Incidental Defects—(AQL = 400 Defects Per 100 Units)

there was a downward trend after which it leveled off. The average quality has remained fairly steady since. The fluctuating dot-dash lines are limiting values for the process average. If the computed process average lies above the upper limit, tightened inspection must be put into effect. If it lies below the lower limit and certain other conditions apply, reduced inspection may be instituted. Actually the contractor requested that we refrain from using reduced inspection on any classification even though he had been eligible. Since it is optional, we acceded to his request. An example of the computation of the limiting values of the AQL follows:

Limiting values for the process average $= \left[\text{AQL} \pm 3\frac{\sqrt{\text{AQL}}}{\sqrt{\Sigma n}} \right] 100$

Hence, for Minor defects:

$$\text{UCL}_{\text{PA}} = \left[1.5 + 3\frac{\sqrt{1.5}}{\sqrt{150}} \right] 100 = 180$$

$$\text{LCL}_{\text{PA}} = \left[1.5 - 3\frac{\sqrt{1.5}}{\sqrt{150}} \right] 100 = 120$$

[Note that on the Minor defect history chart (Chart 2) for the period 4/1/55 thru 4/15/55 the process average is 66/100 units.]

Chart 9 is a history of incidental defects. Notice the prominent peaks and valleys. In October 1953 and June 1954, the contractor was warned of impending tightened inspection and the results are evident. The unfortunate part of incidental defect inspection is that just as the name implies, people think of them only incidentally and have a tendency to ignore them until they cause trouble.

As a result of the installation of the acceptance inspection procedure and the carry-over of its features into other areas of automotive acceptance inspection, Messrs. L. E. Canfield, W. P. Jones, and D. B. Diehl, Chiefs, Inspection Division, Quality Control Branch, and Tank Automotive Branch respectively, of the Cleveland Ordnance District, were commended and received incentive awards for their forward-looking action in devising and selling the original procedure. Finally, it may be said that, entirely to the contrary of what was feared by some, field reports indicated a highly significant improvement in quality.

An Application of a Two-Way X-BAR CHART

PETER E. WEIS

Fasco Industries, Inc., Rochester, N. Y.

Introduction

The number of articles which have been written on the general subject of control charts is extensive. Most of them have dealt with the technique of the use and installation of these charts for applications where only one variable characteristic is to be controlled. It is not intended that this article will outline another application of that type of standard control chart. Here we shall concern ourselves with the application of a two-way $\bar{x}$ chart on which we try to control two variables at the same time. The rigorous approach to the development of this type of technique has been presented in *INDUSTRIAL QUALITY CONTROL*, by Charles R. Hicks, "Some Applications of Hotelling's T," June 1955; and by J. E. Jackson, "Quality Control Methods for Two Related Variables," January 1956.

The usefulness of this two-way chart technique is most apparent where there is a small amount of correlation between the two variables—say where the correlation coefficient is between 0.5 and 0.7, and the variability of the two variables is unequal. Obviously, as the correlation coefficient between the two variables approaches unity, the need for controlling both at the same time diminishes. Some readers may question the over simplification used in this application, and search for a more refined approach to the problem. However, we have found the technique (which has been developed on a trial and error basis) to be extremely useful in controlling the type of operation concerned. We hope that others will find suitable applications.

Description of Product

In order to understand the need for the type of control chart described here, it is best that we give a short description of the product and the problems involved.

Figure 1 shows the construction of a typical automotive circuit breaker. It is a relatively simple device consisting of a short piece of bimetal, approximately one inch in length, one end of which is welded to a terminal on a mounting bracket. The other end has a silver contact welded in place which makes contact with a second terminal on the base. The bimetal deforms on overload currents in such a manner that the contact points open, thus breaking the circuit. This bimetal blade is made on a punch press and the most important characteristic to control in its manufacture is the "oil can" effect. This "oil can" effect is measured in thousandths of an inch in crown height and is controlled by the amount of longitudinal and cross-curve formed in the blade.

The problems in the manufacture of the completed breaker stem from the tolerance requirements of trip time and reset time. The trip time is usually specified in the form of a range of seconds at some specified current. The reset time (after cool-

ing of the bimetal) is also specified in the form of a range of seconds. A typical specification would read that a breaker must trip from 8 to 18 seconds at 27 amperes and reset within 2 to 8 seconds. Depending upon the application of the various breakers, the combination of specifications becomes unlimited both as to current, trip time, and reset time.

Anyone familiar with the requirements of the automotive trade knows that the quantity of such breakers used runs into the millions. Therefore, it is highly desirable to have some method of making all breakers similar, and at the same time, incorporate a method for adjustment to allow for the varying requirements of their trip and reset specifications.

There are two methods for adjusting these blades. The first method, which is tantamount to a coarse adjustment, is to vary the crown height. This variation in crown height primarily affects the trip time with a minor, but noticeable, affect on the reset time. The second method of adjustment, which is tantamount to a fine adjustment, is to adjust the twist of the adjusting ears of the blade. These adjusting ears are shown in Fig. 1 at the outer edges of the bimetal blade. The adjustment of twist affects the contact pressure of the breaker and affects both the trip and reset times almost equally. While the former adjustment of crown height is done by the setting of a punch press and is relatively consistent, the fine adjustment on the twisting ears is done mainly with special twisting tools and is subject to wide variations of operator technique, setting of twisting tools, ambient temperature, skill of the operator, etc.

Some typical applications of automotive circuit breakers are the protection of windshield wiper motors, automotive seat adjusting motors, headlight circuits, tail light circuits, etc. Each application has a different tolerance specification depending upon the circuit it happens to be protecting.

The Problem

The high quantity of production involved makes this product ideally suited for statistical quality controls, and it is the double specification of trip and reset time which we are interested in controlling.

The number of variables involved is extremely numerous. Some of the more important ones are listed below:

(a) The degree of longitudinal curve of the bimetal blade.

(b) The degree of lateral or cross curve of the blade.

(c) The number of twists in the adjusting ears.

(d) The thickness of the bimetal.

(e) The composition of the bimetal.

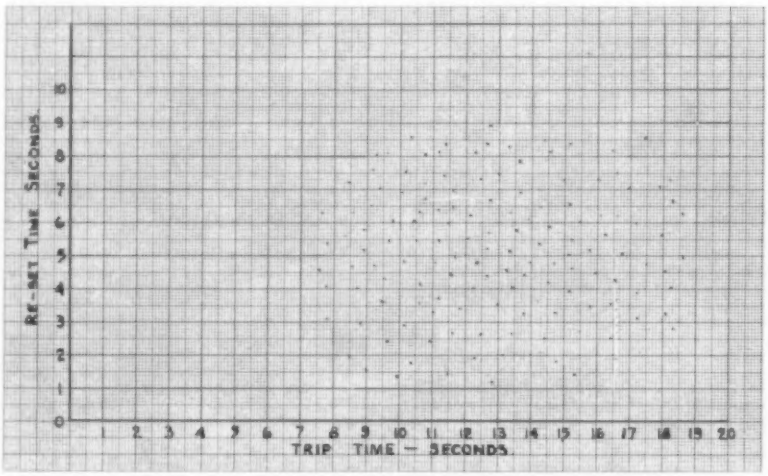
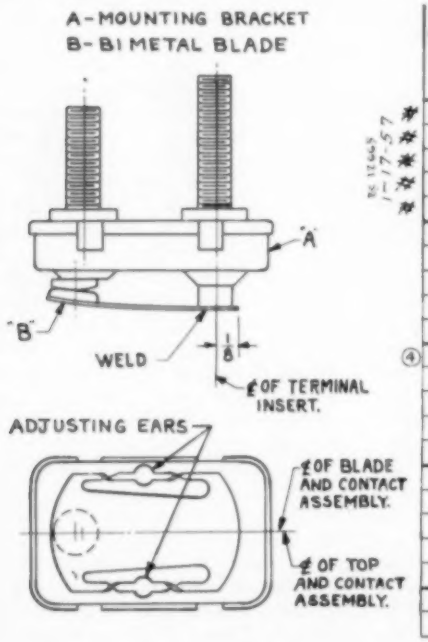


Figure 2—Circuit Breakers Removed from Shipping Stock—100 Percent Sorted Product.



	TEST CURRENT	TRIP TIME AT 77°±3°F	RESET TIME AT 77°±3°F
	27	8-18	2-8
	38	8-18	2-8
	50	8-18	2-8
	64	8-18	2-8
	21	8-18	2-8
	27	8-18	2-8
	38	8-18	2-8
	50	8-18	2-8
	64	8-18	2-8
④	35	8-18	2-8

Figure 1—Typical Automotive Circuit Breaker.

(f) The welding operations (blade to terminal and contact to blade).

(g) The ambient temperature of the area in which the assemblies are being made.

Variables (a) and (b) make up the so-called "oil can" effect of the blade, while (c) primarily determines the amount of contact pressure which affects both trip and reset times.

It is interesting to note here that the degree of twists must be measured in increments of 1/64 part of a circle in order to meet the various requirements of different applications.

Our original efforts toward the control of our product were of a conventional nature. Knowledge of the variability of our product was limited. The most appropriate settings of the controllable variables were determined on a trial and error basis and production was allowed to run with the output being put through automatic electric sorting machines. These sorting machines

cycled each breaker, and if the trip time or reset time was not within specification, the machine would show a red light indicating that the inspector was to discard that particular unit. The obvious disadvantages and high cost of this type of operation suggested the application of statistical techniques of control.

Because the reject rate at final assembly was approximately 20 to 30 percent, and the cost of operating the sorting machines was excessive, we started on a program of analyzing the most important variables to determine which ones should be controlled with average and range charts. It soon developed that variables (a), (b), and (c) were the most important to control. The "oil can" effect (coarse control) is established at the punch press operation and, once established for a particular batch of raw material, can be allowed to run without an excessive amount of variation. The twisting operation (fine control) is a hand operation and is subject to getting out of control. Therefore, conventional Shewhart $\bar{X}$ and R charts were established for both trip and reset times at the ear twisting operation. With two conventional control charts established at this point, our results were fair. The final result was that approximately 50 to 60 percent of all lots were accepted on a MIL-STD-105A sampling basis instead of the requirement of 100 percent inspection. These results brought encouragement to go further and led to the development of "A Two-Way Control Chart."

One of the greatest difficulties in using the conventional control charts was found to be that of maintaining both charts (trip time and reset time) in control at the same time. All too often, it was found that action taken to bring one of the two charts in control had an adverse effect on the other chart. For instance, the trip time chart might signify an "in control" condition; an adjustment to bring the latter into control could very readily throw the former out of control.

The two types of action that could normally be taken when a point got out of control amounted to the following:

- Change the increment of twist on the ears of the bimetal.
- Go back to the blade blanking operation and change the height of the crown.

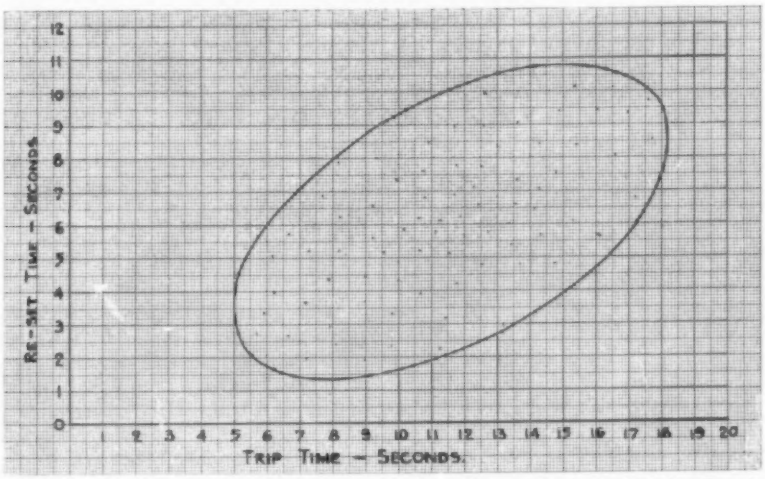


Figure 3—Circuit Breakers Made from One Single Roll of Bimetal Stock—Product Not Sorted.

As mentioned previously, either of the above changes would have an effect on one or both charts. This, of course, presented a problem for the line inspectors and setup men who had the very real problem of analyzing the charts and maintaining a state of control.

A Solution

It was suggested that there might be sufficient correlation between trip time and reset time so that only one chart would need to be maintained. A study of the correlation between these two variables was made by testing a large quantity of circuit breakers removed from shipping stocks. Figure 2 shows that there was little or no correlation between these two variables. Because we felt sure that there must be some correlation, we decided to take a run of breakers manufactured from one single roll of bimetal stock. The results of this test are shown in Fig. 3. It will be noted that there was considerable correlation on this second test. This pointed up the need for more consistency in the raw material, but in the present state of the art, this is not yet possible. Expediency dictated another approach.

One roll of bimetal is sufficient to make approximately one thousand circuit breakers. This represents approximately thirty minutes of production on the production line. Because the problem of maintaining control of individual lots of bimetal presented administratively impossible problems, it was decided that we should make use of this correlation factor in a control of the hour to hour twisting operation, rather than try to maintain individual lot controls identified on two control charts.

Figure 4 shows the correlation results from several different rolls of bimetal stock. It may be seen that if all five rolls were combined in one mass population, there would be little or no correlation. However, it was quite easy to determine what the average slope of the lines of

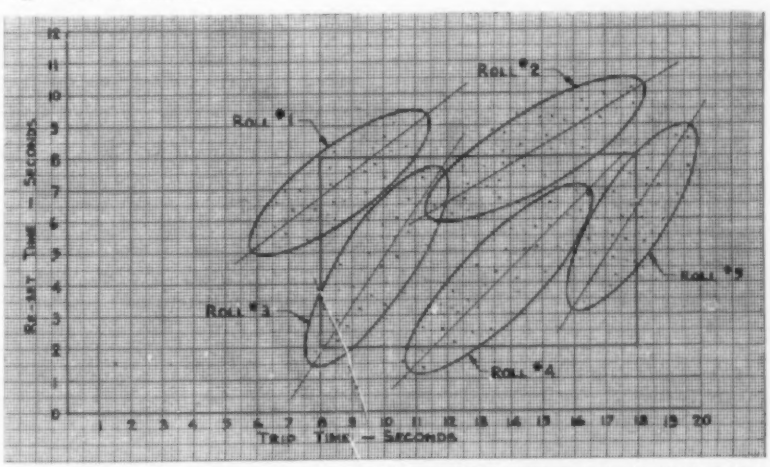


Figure 4—Correlation Results from Several Different Rolls of Bimetal Stock—Product Not Sorted.

M1238-1818 — *Range 18" x 18", working distance 9" to infinity. Reads to 0.001" up to 24" working distance. Protractor ocular reads to 3 minutes of arc. Image is erect.*

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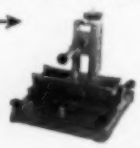

M1236-22— Range 2" x 2", reads to 0.0001". Working distance 5" to infinity. Shown with 19 mm mounting rod, and without telemicroscope. Instrument permits precise coordinate movement of other objects such as photo cells, probes, etc., in place of telemicroscope.

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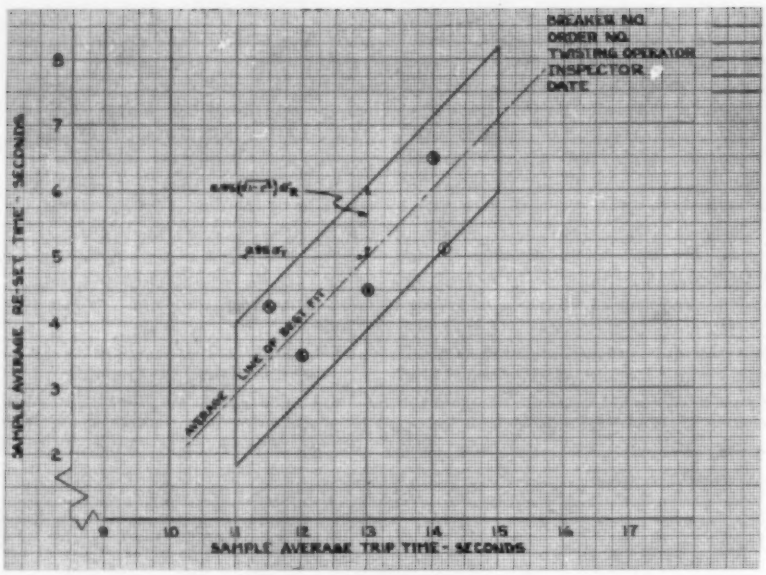

Figure 5—Two-Way Control Chart.

"best fit" would be for various individual rolls taken by themselves. In addition, the correlation coefficients for many different roles of bimetal were determined. These coefficients were averaged to determine an overall value for r. This average* value of r was determined to be 0.65.

The rectangular box marked out in Fig. 4 represents graphically the tolerance of a typical breaker. Taking the center of this square and constructing a line through that center using the average slope of the lines of "best fit," we get the slanting center line of a proposed two way control chart. This line is compatible with the inherent tendency of corrective actions on the two end result variables.

Previous studies on circuit breaker production had given us sufficient information so that we knew the standard deviation for reset time σ_R and the standard deviation for trip time σ_T. In order to adjust for the correlation between the two variables, the standard deviation for reset time was reduced by a factor of $\sqrt{1-r^2}$. Then using the factor A=0.95 (sample size equals 10)† we constructed action limits parallel to this average line of "best fit" at vertical distances of plus and minus $0.95\ \sqrt{1-r^2}\ \sigma_R$. The ends of the parallelogram were placed at horizontal distances of $\pm 0.95\ \sigma_T$ from its center. Figure 5 shows the final form of the control chart.

It will be noted that we now have a control chart with action limits on four sides of a parallelogram. The inspector takes a ten piece patrol check, determines the average trip and reset times, and then plots the point on his control chart by locating the proper ordinate and abscissa. The reader will question the absence of a range chart. This was found to be unnecessary because an excessive range point was seldom, if ever, encountered. The inspectors and setup men soon learned that an increase or decrease of the crown height caused the average point to move horizontally on the chart, and that an increase or decrease in the increment of twist caused the sample average point to travel in the general direction of the slope of the parallelogram. The net result was that there was only one chart for the personnel to watch and as points appeared outside the parallelogram, the proper corrective action was immediately taken in such a way that both the trip and reset times were brought back into the engineering tolerance specifications.

An apparent disadvantage of this type of chart is the lack of an ordering of the points with respect to time that one normally gets with the standard Shewhart chart. This disadvantage was overcome by limiting the number of points on any one chart to ten. The points were num-

*This is just a simple arithmetic average of the 12 values of r. Subsequently, the more refined technique given in Reference 2 was applied to these sample r's, the result being 0.658. It was therefore decided to accept the 0.65 value as a satisfactory approx.

†See Grant, E. L., *Statistical Quality Control*, 2nd Edition, McGraw-Hill Book Co., New York, 1952, Table E.

bered, and on the back of the chart the numbers were referenced to the time of day that the inspection was taken. Ready reference to these notes indicates any possible trend that one might wish to investigate.

Results

It was not long before we found that up to 99 percent of all batches of material were being shipped on a sampling basis rather than on a 100 percent inspection basis. In addition, we were able to get to a 1 percent AQL Guarantee, which was better than we could ever maintain before under our old techniques. The 100 percent sorting equipment with its costly maintenance soon became obsolete and the cost savings in inspection and rework time were substantial.

References

Juran, J. M., *Quality Control Handbook*, McGraw-Hill Book Co., 1951, p. 467-473

Kenney and Keeping, *Mathematics of Statistics, Part 2*, D. Van Nostrand, 1951, p. 223

section briefs

ALBUQUERQUE . . . In October the section heard an interesting talk by Donald W. Thomas, superintendent of quality assurance, Western Electric Co., on his company's quality assurance program.

Marcus Acheson, consulting staff engineer, Sylvania Electric Products Corp., will discuss the subject "Needed development of reliability assurance measures" at the Jan. 16 meeting.

ALLENTOWN-BETHLEHEM . . . Leon Bass, Society President, discussed the nature of tolerances at the regular October meeting held at the Village Inn.

BALTIMORE . . . Dr. W. J. Youden, National Bureau of Standards, is scheduled speaker for the Jan. 14 meeting. Dr. Youden, always a popular speaker with the section, will present interesting and new angles on "Design of experiments" in our attractive new meeting room in Baltimore Memorial Stadium with its unlimited parking facilities.

An increase in section membership is expected to accrue from the stimulus of a fine program for the year, plus the Baltimore-Washington one-day conference held Nov. 15.

BUFFALO . . . Dr. Sheldon, Buffalo, spoke on "Uses of statistical methods in research and development" at the Oct. 28 meeting.

A joint meeting will be held with the St. Catharines section on Jan. 14. Dr. S. Zobel will discuss foundry applications of quality control.

BUZZARDS BAY . . . James Dolby, General Electric Co., discussed "Monte Carlo—key to new methods" at the Oct. 8 meeting. He described the utilization of high-speed computer programming techniques in the solution of quality control and engineering design problems. Kenneth Bennett presided.

CHARLESTON . . . The October meeting was well attended and all present obtained many ideas on how to set up training programs for all levels of employees within an organization from Julian H. Toulouse's talk on "Training in quality control."

The basic course in statistical quality control, postponed due to the flu's attack on instructor and students, was finally started on Nov. 20.

Because the usual meeting date is within a few days of the holiday season, the section will not meet in December.

CHICAGO . . . For all those whose main interest lies in inspection and its techniques, a 16-week course begins on Jan. 14. This course is designed specifically to illustrate ways and means of obtaining measurements rather than the usage of these measurements after being taken. Edwin M. Pearne and his staff will conduct the course which will be held from 7:30-9:30 pm, at the Navy Pier, Room 218. Enrollment fee is $50 for members and $60 for non-members.

CINCINNATI . . . On Oct. 16 Dr. Charles R. Hicks, professor of mathematics at Purdue University, spoke on "Statistics applied to industrial engineering."

On Oct. 30, section members and guests took an interesting and educational trip through the Beckjord Power Station, New Richmond, where they saw a modern high-pressure steam turbine generating plant.

The enrollment in the fall series educational classes totaled 55.

On Jan. 16 we will hear a talk on "Engineering applications of control chart techniques" by S. John Cherry, supt. of power tube manufacturing, Westinghouse Electric Corp.

On Saturday, Jan. 25, the Cincinnati and Hamilton-Middletown sections will jointly present the 7th annual all-day conference. The theme of this year's conference is "The ABC's of Quality Control."

Andrew Stathis has been appointed chairman of the applications committee. This committee assists section members with their quality control problems.

CLEVELAND . . . The fourth annual all-day conference consisted of three levels of lectures; basic and advanced concepts and statistics, and specific industrial applications. In connection with the conference, Anthony J. Celebrezze, mayor of the city of Cleveland, designated the week beginning Nov. 3 as "Quality Control Week in Cleveland."

In January, we will have a joint meeting with the American Foundry Society, at which Dr. W. K. Bock, National Malleable and Steel Castings, will speak.

COLUMBUS . . . Roderick D. Barden will present an illustrated travelogue entitled "Cruising and fishing in Georgian Bay" at the January social meeting. The meeting will include a dinner with favors and door prizes being presented to members and their wives.

CORNING-ELMIRA . . . The month of October witnessed a fine start for the educational program. Thanks are due to Professor Bob Bechofer of Cornell University, Al Stone of Corning Glass Works, and Bob Myers of Westinghouse, who are carrying the ball as instructors.

CUMBERLAND . . . Dr. William R. Pabst, Jr., Department of the Navy, Bureau of Ordnance, discussed "Some misconceptions of acceptance sampling" at the October meeting. He demonstrated the usefulness of the widely used but lately criticized MIL-STD-105A sampling plan tables.

A section of the speaker's table at the first Chicago section general meeting held during September shows (left to right) Dr. Marjorie Sutherland, William Lieberman, Bernard G. Sahlins, and Robert Tenney.

Through the efforts of the section's education chairman, Theodore J. Kight, Frostburg State Teachers College is conducting a night course in statistics during the fall term. More than 60 persons, most from local industries, have registered for the weekly two-hour sessions.

DALLAS-FORT WORTH . . . C. E. Fisher, Society vice president, presented a provocative talk on quality assurance in the Bell System on Oct. 10.

The three day seminar on advanced techniques, problem solving, and a discussion of organizational and managerial methods sponsored by the local chapter was eminently successful. The seminar was aimed at upper echelons of management, being restricted to managers of QC or above.

Don't miss the Jan. 9 meeting—Herb Epstein of CVA will present a challenging subject "Controlling quality control."

The course in advanced statistical quality control is underway. An attendance of 30 was registered at the first meeting.

Jan. 14 is the starting date for the basic SQC course. It will be an 8-week course meeting each Tuesday from 7-9 pm.

DENVER . . . Richard A. Carlson, manager of special manufacturing department in Remington-Rand Univac Div., Sperry-Rand Corp., spoke on "Reliability from a production viewpoint." He emphasized that reliability is important because the defense services are demanding it and commercial concerns are now including high reliability standards in their requirements. The process of educating all employees in order that they understand the part they play in reliability was also emphasized.

The section will welcome another manufacturing company to its area at the January meeting. Joseph Sbordone of Ramo-Wooldridge Corp. will be the guest speaker.

EVANSVILLE-OWENSBORO . . . C. G. Schelly, managing editor of the Wilke Foundation, presented "The Story of Measurement" at a dinner meeting held at Evansville College on Oct. 14.

Dr. Howard Wilson, educator, lecturer, and training consultant, will be the speaker at the Jan. 21 meeting to be held in Owensboro. His subject will be "Overcoming resistance to change."

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GREATER MUSKEGON . . . Fifty-seven members and guests had the pleasure of hearing Society President Leon Bass at a dinner meeting on Oct. 10. Mr. Bass' topic "The true meaning of a blueprint tolerance" was further enhanced by colored slides. Mr. Bass also reviewed the section's work program with the officers.

An educational program in QC was sponsored by the section through the Continuing Education Service Department of Michigan State University. Professor Jagdish Rustagi of the Statistical Department of the University was the instructor. Certificates of attendance and performance were awarded.

HAMILTON . . . The Oct. 8 seminar, jointly sponsored by CIMA and the section, was voted an unqualified success by the large gathering who heard William A. MacCrehan of Bendix Aviation Corp., present his "Quality control for management" subject. Thanks again "Bill."

The Jan. 15 jointly sponsored dinner meeting with the University of Western Ontario section is a "repeat" on last year's very popular panel discussion. This is one meeting when management representatives do not hesitate to express their own personal outlook on SQC. Make this a MUST on your date pad.

HAMILTON-MIDDLETOWN . . . The executive committee held their meeting Oct. 15.

Mr. Burt, president of the National "You" Organization, presented a very interesting talk at the October meeting.

The Hamilton-Middletown and Cincinnati sections will hold a joint meeting in January. It will be an all-day conference at the Netherland Hilton Hotel, Cincinnati, on Jan. 25.

HARTFORD . . . A basic course in SQC to commence circa the second week in January, will be conducted by Frank Hauman, vice chairman of the section, and will be held at the East Hartford (Conn.) High School.

HUNTSVILLE . . . The Huntsville and Birmingham sections were co-sponsors for the 3rd annual quality control conference at the University of Alabama. A varied and extensive program was presented.

There will not be a local meeting for the month of December.

INDIANAPOLIS . . . Leon Bass, Society President and manager of quality control, Jet Engine Department, General Electric Co., gave a very interesting talk on "Statistical methods for the engineer" at the Nov. 12 meeting.

The 1957-58 motto as adopted by section president Tom Turner is "Meet More Members." Get acquainted with your fellow section members now.

Everyone is invited to the Third Annual Indiana Clinic, to be held Jan. 24 at Butler University, Indianapolis.

KANSAS CITY . . . The Oct. 17 meeting featured C. Earl Hovey, patent attorney. Mr. Hovey's subject was "Adaptation to change and its influence on quality control." Prior to the regular dinner meeting, members had an opportunity to browse through the interesting product display exhibit of the Gustin-Bacon Manufacturing Co., arranged by quality control manager Frank E. Lair.

LANSDALE . . . On Oct. 10 a lecture was given by Dr. Michael S. Free of Smith, Kline, and French. Color slides were used to illustrate his subject "Clinical statistical studies." His talk was received with much interest and enthusiasm, as was the film which followed entitled "Ultrasonic Inspection."

Our Jan. 9 meeting will be "Education night" and will be devoted entirely to the basic concepts of quality control and statistical methods. The audience will be composed of students from local high schools and colleges. Our guest speaker will be Daniel Meckley, III, of the York Corp., whose topic will be "Your future in quality control." His lecture will be followed by two films—"Fundamentals of Quality Control" and "Precisely So." It is hoped that this innovation will help send some of these students along the road to quality control.

LOS ANGELES . . . The October meeting was inspired by General Caldara's feeling for quality control. In addition, his sincerity and burning desire to increase the flight safety of all manned and unmanned air and space vehicles was in every word of his talk.

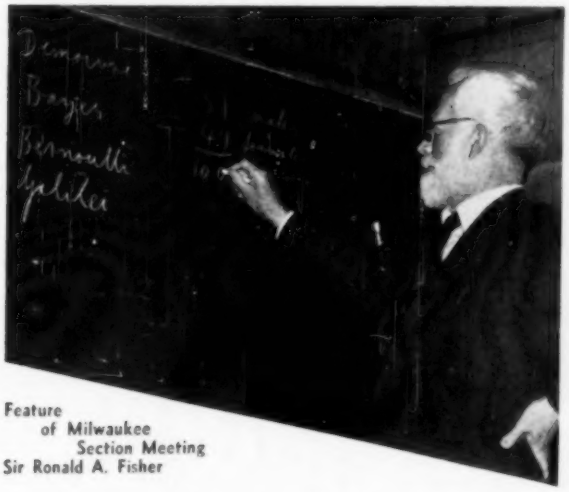
LOUISVILLE . . . The management night dinner held in October was most successful with an excellent turnout of members and management personnel of the companies repre-

sented in the section. Unfortunately, illness of the scheduled speaker required a last minute change in the program.

MEMPHIS . . . Management night was held Oct. 30 with Dorian Shainin as speaker. Mr. Shainin's topic "Management breaks through industrial problem barriers" proved to be interesting, entertaining, and educational to the capacity audience at the meeting.

MID-HUDSON . . . Guest speaker for the October dinner meeting in Rhinebeck was A. U. Sternlof, supervisor, quality control electrical cable works, U. S. Steel Corp.

The Jan. 7 meeting, Anchor Inn in Poughkeepsie, will find Mr. W. Kehayis addressing the group on "Fundamentals of machine capability as applied to electronic test equipment."



Feature
of Milwaukee
Section Meeting
Sir Ronald A. Fisher

MILWAUKEE . . . Approximately 225 members and guests filled the Marquette University Medical School Auditorium to hear an address by Sir Ronald Fisher, University of Cambridge, England. Sponsored by the Milwaukee section of ASQC and the Milwaukee chapter of ASA, Sir Ronald's address on "The Semantic nature of probability" gave an indication of the varying theories prevalent in the field of statistics and their interpretations by different statisticians over the last two centuries.

After the program, the members and guests retired to the Hotel Stratford for a social hour followed by a buffet supper. The monthly educational session after supper was on the "t-test."

MINNESOTA . . . An active October included a highly successful 6th annual clinic, a joint meeting with the Twin Cities chapter of ASA attended by 300 people, and notable progress in the organization of the subsection at Rochester, Minn.

The scene of the Jan. 14 meeting will be Room 320, Coffman Memorial Union, University of Minnesota. Brent C. Jacobs, Jr., Minneapolis-Moline, will speak on "Machine capabilities."

MONTREAL . . . On Oct. 16 Bob Chateauneuf of the Singer Mfg. Co. gave a very interesting talk on "Quality control pays off in woodwork." It was most interesting to see how modern SQC methods are applied to this ancient art.

On Oct. 19 members of the executive committee travelled to Brockville for the purpose of establishing a subsection in the area.

Peter F. Wade of the Aluminum Co. of Canada will address the section on Jan. 15. He will talk on "Statistics in industrial experimentation."

NEW HAMPSHIRE . . . The section shared its meeting with the AIIE on Oct. 29. Features included a trip through the Arwood Mfg. Co., Tilton, and an interesting talk by Professor Theodore Brown entitled "Engineers, small samples, and decisions." Nineteen industries were represented by the 68 participants.

NORTHEASTERN INDIANA . . . The Jan. 8 meeting is one you can't afford to miss. This meeting sets forth an art we are all familiar with but which is fast becoming revolutionized to the needs of today—the art of inspectioneering. N. G. Meagley, manager of QC, Kaiser-Willys, will present this timely subject. All persons connected with QC and Inspection are invited to attend this meeting.

OMAHA-LINCOLN . . . Twenty-five members and guests enjoyed a tour of the Allied Chemical & Dye Corp. on Oct. 11. The tour was followed by a fine dinner in the plant cafeteria. V. J. Ruck of Allied Chemical was in charge of the program.

PHILADELPHIA . . . A tour of the Standard Pressed Steel Company's facilities in Jenkintown, was conducted by the company on Oct. 17. The tour was of great interest to all those attending, especially those interested in the manufacture of pressed steel parts.

RHODE ISLAND . . . At the October meeting members and guests were privileged to hear Frank Caplan, Jr. of Westinghouse Electric Corp. speak on "Process control in a job shop."

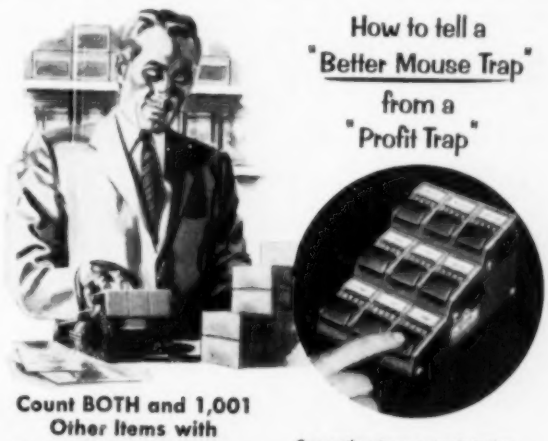
The well known Simon Collier, director of quality control, Johns-Manville Corp., will be the featured speaker at the Jan. 16 meeting. A pre-meeting dinner is scheduled for 6 pm.

ROCHESTER . . . Save this date—Feb. 18. Why? It will be the date of the 14th Annual Quality Control Clinic to be held at the Rochester War Memorial.

ST. LOUIS . . . The management meeting was a huge success on Oct. 18. This was a joint meeting with the Society for Advancement of Management.

Instead of our usual monthly meeting for Jan. 17, the section has arranged to hold their annual party. This will be ladies night and all the wives and friends are being invited. All members are requested to hold this night open.

SAN ANTONIO . . . C. E. Fisher, Society vice president, was guest speaker at the October dinner meeting. Mr. Fisher addressed 72 members and guests on "Quality assurance." Ten top management officials of government and local industry were special guests of honor for this occasion. The ultimate success of this meeting was indicated by the active participation of all in the informal discussion which followed Mr. Fisher's presentation.



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SECTION CALENDAR (DECEMBER 20—JANUARY 31)

SECTION	DATE	PLACE	TIME	SUBJECT	SPEAKER
Albuquerque	Jan. 16	University of New Mexico	7:30 pm	Needed Development of Reliability Assurance Measures	Marcus Acheson, Sylvania Electric Products Corp.
Baltimore	Jan. 14	Baltimore Memorial Stadium	8:00	Design of Experiments	Dr. W. J. Youden, National Bureau of Standards
Binghamton	———	Vestal American Legion	7:00	The Overlooked Technique of Properly Selecting a Sample	E. B. Godsey, Corning Glass Works
Buffalo	Jan. 14	St. Catharines, Ont.		Foundry Applications of Quality Control	Dr. S. Zobel
Buzzards Bay	Jan. 14	Continental Screw Company	8:00	Assigning Responsibility for Quality in Textile Manufacture	C. D. Ferris, Mohasco Industries
Charleston	Jan. 16	South Charleston Recreation Center	8:00	Story of Measurement	The DoALL Company
Chicago	Jan. 14	Navy Pier, Room 218	7:30	Measurements and Their Techniques (16 week course)	Edwin M. Pearne and Staff
	Jan. 22	Lawson YMCA	6:00	Quality Control under Full Automation	———
(Fox Valley)	Jan. 21	Club Arcadia, St. Charles	5:30	Quality Control Management Reports	Arthur Bender, Delco-Remy Div., GMC.
Cincinnati	Jan. 15	Engineering Society Building	8:00	Engineering Applications of Control Chart Techniques	S. John Cherry, Westinghouse Electric Corp.
	Jan. 25	Netherlands Hilton	9-5	All-day conference, "The ABC's of Quality Control"	———
Cleveland	Jan. 9	———	8:00	Is Quality Control Old Stuff in a Foundry	Dr. W. K. Bock, National Malleable and Steel Castings
Columbus	Jan. 15	Lincoln Lodge	6:30	Social Evening	Roderick D. Barden
Corning-Elmira	Jan. 14	Corning	8:00	Design of Industrial Experiments	Prof. Charles R. Hicks, Purdue University
Cumberland	Jan. 9	———	6:30	Resampling in a Chemical Process	E. J. Delate, Du Pont
Dallas-Fort Worth	Jan. 9	Arlington State Teachers College	8:00	Controlling Quality Control	H. B. Epstein, Chance Vought Aircraft
Denver	———	———	———	Quality Control Organization at the Littleton Plant of Ramo-Woolridge Corporation	Joseph Sbordone, Ramo-Woolridge Corp.
Evansville-Owensboro	Jan. 21	Owensboro	7:30	Overcoming Resistance to Change	Dr. Howard Wilson, Consultant
Greater Muskegon	Jan. 9	Doo Drop Inn	6:30	———	Robert Kantoz, UAW-CIO Representative
Hamilton	Jan. 15	Brant Hotel, Brantford	6:30	Panel Discussion—Managements Outlook on SQC	J. W. Jolly, Standard Tube & T.I., Ltd.
Hamilton-Middletown	Jan. 8	Pillsbury Mills	8:00	———	———
Hartford	Jan. 21	Club Aiden, Hartford	8:00	Organizing for Reliability	Ralph E. Kuehn, IBM
Indianapolis	Jan. 24	Butler Universty, Indianapolis	6:30	Third Annual Indiana Clinic	———
Lansdale	Jan. 9	Eagles Auditorium	7:30	Education Night	Daniel Meckley, III, York Corp.
Los Angeles	Jan. 16	Rodger Young Auditorium	6:00	QC as Viewed by Purchasing and Purchasing as Viewed by QC	———
Louisville	Jan. 13	General Electric Appliance Park	8:00	Do You Have a Unified QC Program	Fay Carlson, Warner Brake & Gear
Mid-Hudson	Jan. 7	Anchor Inn, Poughkeepsie	7:00	Fundamentals of Machine Capability as Applied to Electronic Test Equipment	W. Kehayis
Milwaukee	Jan. 6	Hotel Stratford	6:00	Finding the Facts Before Setting the Specification	Dr. J. H. Toulouse, Owens-Illinois Glass Co.
Minnesota	Jan. 14	University of Minnesota	7:30	Machine Capabilities	Brent C. Jacobs, Jr., Minneapolis-Moline
Montreal	Jan. 15	CIL Bldg.	8:30	Statistics in Industrial Experimentation	Peter F. Wade, Aluminum Co. of Canada
Northeastern Indiana	Jan. 9	Chamber of Commerce, Fort Wayne	8:00	The Art of Engineering	N. G. Meagley, Kaiser-Willys
Omaha-Lincoln	Jan. 10	Marchio's, Omaha	7:00	———	Oliver Karraker, Western Electric Co.
Rhode Island	Jan. 16	Providence Engineering Society Bldg.	8:00	———	Simon Collier, Johns-Manville Corp.

Rochester	Jan. 7	Chamber of Commerce	6:15	Progress in Optical Gaging Techniques	James Huff
	Jan. 21	Chamber of Commerce	6:15	How Quality Control is Used by the Product Designer	Dr. Howard S. Coleman
St. Louis	Jan. 17	——	——	Annual Party	Reserve this date for you and your lady
San Antonio	Jan. 14	——	——	——	J. C. Dickson, Humble Oil Co.
Scranton-Wilkes-Barre	Jan. 14	Deitrick, Scranton	6:30	Variable Charts	Graham Morse, Jones & Lamson Co.
South Bend-Mishawaka	Jan. 16	Bendix Legion Post, South Bend	7:30	Maintenance of Reliability and Equipment	C. C. Capel, Bell Telephone Laboratories
South Texas	Jan. 8	Ben Milan Hotel	7:15	Controlling Quality of Short Runs	Harmon S. Bayer, Consultant
Southern Connecticut	Jan. 8	Norden-Ketay Corp., Milford	——	——	Howard Burbank, Norden-Ketay Corp.
Toledo	Jan. 9	Angelo's Restaurant	6:30	Statistical Aspects of Tolerance	Morris M. Lightstone, Chrysler Corp.
Toronto	Jan. 8	University of Toronto	8:00	Work Simplification	F. W. Duff, British American Oil Co.
	Jan. 22	The Sign of the Steer	6:00	Industrial Television and its Application to QC	Canadian General Electric Co.
Winnebago	Jan. 13	Elk's Club, Appleton	5:00	——	——
Worcester	Jan. 16	——	6:30	Application of Statistics to Industry	Leroy H. Lindgren, Joy Manufacturing Co.

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SCRANTON-WILKES-BARRE . . . Pennsylvania State University Extension Center in Wilkes-Barre, in cooperation with the section, is offering a course in SQC for the first time in the Wilkes-Barre area. In the past few years, the course was offered in Scranton only. This year it is offered at the college centers in both cities.

R. Zingerman, manager of QC at Eureka Printers, will teach at the Scranton Center. Mr. Zingerman is chairman of the Section.

C. David, manager of quality control at Kanaar Corp., will teach at the Wilkes-Barre center. Mr. David is program chairman of the section.

This course is designed for persons interested in learning how to use simple statistical tools for analyzing and controlling quality of industrial products.

SOUTH BEND-MISHAWAKA . . . Chairman J. F. Gyoles successfully moderated the first of the winter series of his original "Quality control problem" forums on Oct. 3. Many problems were presented and the solutions were both interesting and informative.

J. E. Sorenson, asst. quality manager for the Aeronca Corp. of Middletown, Ohio, was the featured speaker at the Oct. 17 meeting. His talk was entitled "The mathematical theory of quality control."

SOUTH TEXAS . . . The section met in joint session with the local section of the American Institute of Industrial Engineers on Oct. 9 to hear C. E. Fisher of the Bell Telephone Laboratories speak on "Quality assurance." The excellent attendance by both groups emphasized the interest in this topic.

SOUTHERN CONNECTICUT . . . The section was host at the 11th New England Conference held in Bridgeport Oct. 16-18. Because of the conference, no regular October meeting was held.

The January meeting will be a plant visitation to the instruments and systems divisions of the Norden-Ketay Corp. Howard Burbank, quality control engineer, will be the speaker.

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TOLEDO . . . Several representatives from management attended "management night" observed at our October dinner-meeting. Harmon S. Bayer discussed "How to organize a quality control program that pays." He stressed the importance of management's cooperation in the effective operation of a statistical quality control program and the responsibility for quality of a product lies with the men who produce it. A dynamic speaker, Mr. Bayer is a QC consultant from Detroit and is also chairman of the Michigan section. Ray E. Crouse was moderator for the event.

"Statistical aspects of tolerance" will be the topic of consideration by Morris M. Lightstone, Chrysler Corp., at the Jan. 9 meeting to be held at Angelo's Restaurant at 6:30 pm.

TORONTO . . . On Oct. 9 "The GE master control system" was extensively explained by N. P. Demos. Viewpoints on engineering probability problems were given and it was made clear that it is much better to work to statistical limits, than to reset machines every time a defective piece is made. The attendance was very satisfactory taking into account the raging flu epidemic.

A very interesting plant tour was offered the section recently. The staff of Don Valley Paper Mill, Beechwood Drive, showed section members the manufacturing steps that bring paper from the pulp stage to finished product.

WINNEBAGO . . . The regular meeting was held Oct. 14 at the Elk's Club, Appleton. The training session preceded the dinner meeting. The speaker for the evening was Maynard S. Renner, staff assistant to the vice president, Dewey & Almy Chemical Co., Cambridge, Mass. Mr. Renner spoke on "Some considerations in the reel sampling of paper." Fifty-six members and guests were present at the meeting.

The first meeting in '58 will be held on the 13th at the Elk's Club, Appleton.

YOUNGSTOWN . . . The section met Oct. 3 to hear Dr. Lloyd S. Nelson, specialist in industrial statistics of the General Electric Lamp Division. His subject was "Rapid analysis of engineering data." Dr. Nelson discussed relatively simple statistical tests that are applicable whenever pairs of treatment are to be compared.

. . . SIGNIFICANT DIFFERENCES

. . . Baltimore — Francis J. Cullen, industrial statistician, National Plastic Products Co., is the third member of the section to contribute to the teaching of quality control and statistics at universities in the area. Mr. Cullen is on the evening school faculty of Loyola University.

. . . Cleveland—Howard Streich has returned to Cleveland and is now quality control coordinator with the Swartout Co.

Dr. W. E. Gaunt is now director of laboratories at Strong, Cobb, and Co.

. . . Corning-Elmira—Jack L. Rhodes has been named quality control manager of the Electrical Products Div., Corning Glass Works.

. . . Dallas-Fort Worth—Convair-Fort Worth recently announced that J. L. Coburn is returning. Mr. Coburn was chairman of the first Dallas-Fort Worth section. All of Jim's friends welcome him back.

. . . Hartford—Everyone wants to get into the act—everyone meaning officers that is.

Chairman Ernest Bozenhard accepted the post of chief inspector at the Greenwood Plant, Underwood Corp.

Past chairman Charles Kropp is now source inspector at Hamilton Standard Corp.

Vice chairman Frank Hauman was named supervisor of quality control engineering at Royal McBee Corp.

Membership chairman Herbert A. France, Jr. was recently appointed quality manager of E. Ingraham Co.

Treasurer MacChesney Desmond has been named foreman of the metrology division of the Hamilton Standard Propeller Corp.

. . . Los Angeles—Warren A. Seward has transferred to the Autonetics Division of North American Aviation, Inc., Downey, and is serving as supervisor of statistical quality control. In his new position, Mr. Seward is responsible for the direction of SQC activities in the manufacturing and engineering areas.

. . . Memphis—Maurice L. Brandon, section secretary, has been transferred by Kimberly-Clark Corp. to a new plant at New Millford, Conn., as laboratory and quality control supervisor.

. . . Milwaukee—J. Heintskill, A. O. Smith Co., has recently transferred from the automotive quality control group to the Cadillac auto-frame production group.

Section members are very active in teaching QC courses at various local institutions. R. Byrnes is at the University of Wisconsin-Milwaukee, Irv Schoeninger is at the Milwaukee Vocational School, and Arnold Jakel is at the South Milwaukee Vocational School and the Milwaukee School of Engineering.

. . . Montreal—Bill Lewis of Imperial Tobacco of Canada, and our hard working membership committee chairman, is being transferred to the Hamilton Plant. Our loss is Hamilton's gain and the best of luck to you, Bill.

. . . South Bend-Mishawaka—Fred De Vries, section treasurer, was recently promoted from quality manager to plant manager of the Ivalon Division of the Simonize Co., Benton Harbor, Mich.

. . . Toledo—Fred J. Weber, National Carbon Co., has been appointed by section chairman Hilton C. Fetting to write an article explaining the activities of the section as well as some phase of SQC. This article will appear in the March issue of "Toledo Technical Topics," a monthly periodical published by the Toledo Technical Council.

SUPERVISOR'S CIRCLE

PAUL A. ROBERT, *Editor*

Precision Products Co. of Cincinnati, Box 130, Norwood 12, Ohio

Use Of The Visual Screening Instrument To Improve Effectiveness Of Visual Inspection

DR. HERMAN SAGER, O.D.

Sperry Gyroscope Co., Great Neck, Long Island, N.Y.

The majority of job classifications today are those which require clear, efficient, and comfortable vision at the job working distance which is usually 10 to 20 inches from the eyes. Many of these jobs require meticulous accuracy and some even require precision microscopic observation. Spoilage of a part or oversight of a flaw due to a visual error can be very costly; sometimes amounting to thousands of dollars.

Visual inspection can be defined as the aided or unaided observation of details without measurement to determine the conformance and completeness of the part or finished product.

Visual inspection requires the following to be performed:

a) Must be able to work with parts of machining tolerances that may at times range from ten thousandths of an inch to ten millionths of an inch.

b) Flaws of the minutest detail must be detected such as dust particles, burrs, chips, and surface irregularities.

c) See whether all washers are firmly compressed.

d) The electrical connections be mechanically secure. Check must be made for cold solder joints and solder splashes.

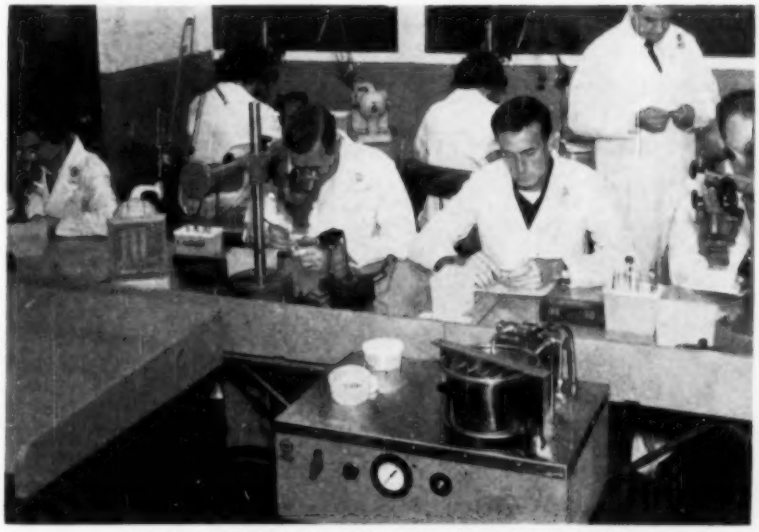

Figure 1—Visual Inspection of Small Parts Before Final Assembly.

Editor's Comments

The proper examination of the inspector's eyes is as important to visual inspection as the control of gages to mechanical inspection.

Since visual characteristics constitute the largest single category in the field of quality control, it behooves the quality control manager to take an interest in the scientific methods and devices available for improving the effectiveness of the visual inspection in his plant.

This article by Dr. Sager describing the visual examination program at Sperry Gyroscope Company is recommended reading for all chief inspectors, quality control managers and engineers interested in improving visual inspection.

Figure 2—Vision Technician Gives Occupational vision test to new employee. Instrument is used to determine if employee's eyesight is suitable for certain types of work.

There must be at least 1/16 of an inch between solder connections.

e) May at times be required to use microscope ranging from 10x power to 45x power.

f) Be able to read blueprints and be able to compare appearance of finished product with picture of part.

g) Detect any flaws in paint finishes.

h) Examine castings for imperfections at times using "black light" to fluoroscope the material.

i) Examine for rust formation on parts such as bearings and also to observe by reflected light uniformity of bearing surfaces.

j) See that codings and color markings have right values.

k) Required to distinguish visually the various types of metals used.

The above are just a few of the major tasks that have to be performed by visual inspection. It should then be quite obvious how important a role good vision plays in this important function of industrial production.

The problem that then exists is how to select those employees or applicants who have the satisfactory near-vision skills to perform these tasks quickly and accurately.

Checking an employee's vision with a wall chart at 20 feet gives no indication how the eyes will perform at a close range. Therefore, it becomes necessary to make use of a visual screening device which contains a battery of near point tests that will give the answers as to the true aptitude or ability of the eyes to function efficiently at the work distance.

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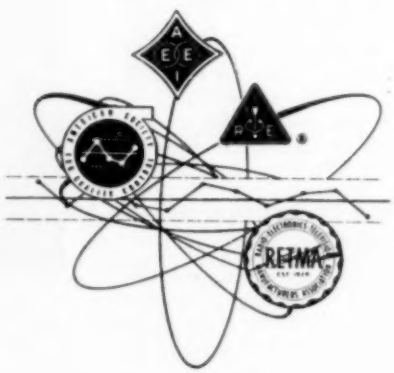

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1957 Shewhart Medal Nominations

Nominations are now being received by the Shewhart Medal Committee for consideration with respect to the 1957 Shewhart Medal Award. Previous Medalists are:

L. E. Simon	— 1948	E. L. Grant	— 1952
H. F. Dodge	— 1949	H. G. Romig	— 1953
M. A. Brumbaugh	— 1950	E. G. Olds	— 1954
G. D. Edwards	— 1951	W. E. Deming	— 1955

Mason E. Wescott — 1956

A letter of notification is being sent to all ASQC Section chairmen. Any member of the Society is privileged to make a nomination for this honor. It is important, however, that any nomination be accompanied by suitable biographical and other information supporting the nomination so that the Committee will be able to give adequate consideration to the qualifications of the nominee.

Nominations should preferably be forwarded to the Shewhart Medal Committee through the Chairman of the local Section, but may be sent direct with supporting information (10 copies, please) to the Chairman of the Medal Committee, Lloyd A. Knowler, Department of Mathematics and Astronomy, State University of Iowa, Iowa City, Iowa. Nominations received by the Medal Committee on or before December 31, 1957, will receive due consideration.

There are several such instruments on the market to-day that can be used for this purpose; such as the Keystone *Telebinocular,* the American Optical Company *Sight Screener,* and the Bausch & Lomb Optical Company *Ortho-Rater.*

These instruments are geared to give a performance profile not only of the employee's distance vision accomplishments, but what is even more important to us, his near visual performance.

Having obtained a vision screening profile of the employee by means of this visual analysis test, the following knowledge can be ascertained regarding his performance:

1. Visual acuity at distance and near.
2. Extrinsic muscle balance of the eye at distance and near.
   (a) Whether a suppression or suspension of vision of one eye exists thereby influencing a lack of good binocular vision (seeing simultaneously with both eyes) which would be required in jobs requiring use of both eyes such as binocular microscopic inspection.
   (b) Or whether a convergence or accommodative (focusing) inefficiency exists.

   This type of anomaly would affect an employee's continuous concentration at his near job and would result in the employee manifesting numerous types of symptoms and complaints such as visual fatigue, diplopia (double vision), twitching of lids, tearing, reddened lid margins, frontal headaches and a host of other such symptoms.
3. A color vision test which quite accurately will divulge an employee's ability to differentiate colored mixtures. The color vision skill is important in order to identify colored wires from one terminal to another. At times there may be as many as 5 to 200 colored wires of various shades inter-twined in an electrical harness.
4. A test of depth perception is included in this battery of tests. Knowledge of employee's ability to judge objects in space would be of immeasurable advantage to the inspector or assembler who has to use a binocular magnifier or miscroscope.

At the Sperry Gyroscope Company we have in the past fourteen years made extensive use of the Bausch & Lomb Ortho-Rater instrument. It has given us the advantage and comfortable knowledge that all applicants and employees in our manufacturing areas have the proper visual skills to perform the necessary job. When we first began our visual testing program there were two significant discoveries that were made as a result of several studies.*

*Coleman, J. H. and Feinberg, R., "Vision Tests for Inspectors Insure Good Placement," *Factory Management & Maintenance,* January 1954.

Twelfth Midwest Quality Control Conference

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- *Initiation and Progress of a Quality Control Program*
- *Plastics in Industry*
- *Experimental Designs and Variance Components*
- *Quality Control and Production Efficiency*
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Administrative Applications Division News

"Management by Exception" will be the theme of the second annual conference of the division to be held Feb. 7-8 at the Carter Hotel, Cleveland, Ohio. Nineteen experts from all fields of experience in management and statistical methods will discuss the many facets of basic management problems. They will present practical applications of statistical quality control to modern management operations in three concurrent program series: management problems, industrial engineering and research approaches, and new horizons. The compact conference is designed to be a guide-light for the implementation of fundamental improvements in administrative operations. The program will include, among others, authorities from Case Institute of Technology, Massachusetts Institute of Technology, Rath and Strong Company, Monsanto Chemical Company, Illinois Bell Telephone Company, University of Minnesota, Institute of Advance Study at Princeton, and University of Chicago.

1. It was found that the employees with good vision for the job were rated the highest by the foreman in the performance of their job.
2. That approximately 50% of the employees of the various departments tested required further examinations for glasses or that they required changes in the prescription glasses they were wearing at the time.

These employees were totally unaware of this need and attributed their symptoms and poor performances to various other factors. After they had obtained the necessary glasses and proper vision they showed a marked improvement in the performance ratings maintained by their foreman.

As vision changes with age it is important that a periodic visual screening be performed at least every two years.

Today we can safely say that the visual efficiency of our shop personnel ranks among the highest of all industrial companies in the country. Supervision is elated to know that their personnel have the necessary vision for the job and thus are able to exclude vision as a reason for poor work, spoilage and high rejection rate.

It is important that all industries of more than one hundred employees have such instrumentation for vision testing in their plant.

Aircraft Division News

The Aircraft Division, which has been planning regular meetings to coincide with its Board Meetings, has released information that future conferences will be held as follows:

- The 1958 Aircraft Division Conference will be held in Dayton, Ohio, on November 17 and 18 in cooperation with the Dayton Section. Max Astrachan is Chairman of the Dayton Conference Committee.
- The 1959 Conference is to be held in Dallas in cooperation with the Dallas-Fort Worth Section.
- The 1960 Conference is scheduled for the East Coast. The Baltimore Section is cooperating in development of plans for this Conference.
- The 1961 Conference is tentatively scheduled for Seattle in cooperation with the Seattle Section.

It is reported that the plans for the Dayton Conference are beginning to shape up very well.

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. . . ***6-8—4th National Symposium on Reliability and QC in Electronics, Hotel Statler, Washington, D. C., sponsored by RETMA, AIEE, IRE, ASQC, contact Richard M. Jacobs, Publicity Chairman, RCA, Box 33, Camden, N. J.***

. . . **7-9**—Salary and Wage Administration, Marquette University, fee $75, contact Dr. Russell L. Moberly, Management Center, Marquette University, Milwaukee 3, Wisconsin.

. . . ***12-23—Statistical Methods for Process Development, Harvard Business School, sponsored by Chemical Division, ASQC, fee $375, contact Richard S. Bingham, Jr. (SMPD), The Carborundum Co., Research & Development Division, P.O. Box 337, Niagara Falls, N. Y.***

. . . **13-17**—Supervisory Development Course 3, given in three one-week units (Jan. 20-24, Feb. 24-28), Penn Sherwood Hotel, Philadelphia, sponsored by AMA, contact Course Registrar, American Management Association, Inc., 1515 Broadway, New York 36, N. Y.

. . . **14-15**—Yankee Instrument Fair & Symposium, Hotel Bradford, Boston, Mass., sponsored by ISA, contact ISA-Boston Section, Inc., Box 282, Boston 1, Mass.

. . . **27-Feb. 6**—Higher Management Course, Los Angeles campus of the University of California, fee $350, contact Edward P. Coleman, University of California Extension, Engineering, Los Angeles 24, Calif.

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FEBRUARY

. . . **3-4**—National Conference on Progress and Trends in Chemical and Petroleum Instrumentation, Wilmington, Dela., sponsored by ISA. Contact, H. S. Kindler, Director of Technical Programs, Instrument Society of America, 313 Sixth Avenue, Pittsburgh 22, Pa.

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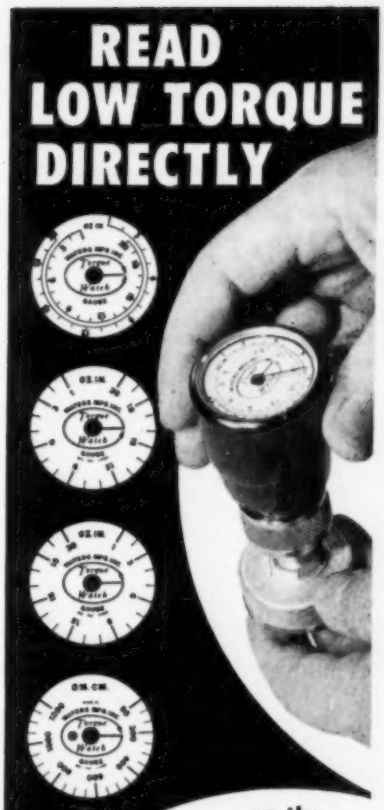

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BOOK REVIEWS

W. D. Baten, Editor

26 University Drive, East Lansing, Mich.

DIGITAL COMPUTER PROGRAMMING, by D. D. McCracken, vii plus 253 pages, $7.75, published by John Wiley & Sons, Inc., New York, 1957. Reviewed by K. J. Arnold.

For stored program computing machines, we now have the first book on programming which is neither a detailed technical manual for a particular machine nor a vague discussion of what a programmer might do. It will be hard for anyone to produce a better book for any of several purposes which this book is designed to fulfill.

The author starts his preface with, "This book is written for the person who needs to know how problems are solved on a modern stored program computer," but later uses the fully justified, "for the person who wants to know . . ." Even a casual reader will effortlessly gather a large amount of information. The serious reader will find exercises at the end of each of 15 of the 18 chapters and will discover, in working out the exercises, the fine points which he may have missed on first reading.

A "paper" machine, the TYDAC (Typical Digital Automatic Computer) is invented with a character which fits all of the present stored program machines in all essential characteristics. Certain facets of TYDAC's character are peculiar to a subclass of such machines but throughout the text, it is shown that TYDAC, using its Clark Kent rôle can do everything it can do in its Superman rôle. We are, of course, shown how Superman can do the jobs more easily with two index registers, floating point orders, etc. Even the fact that a zero in TYDAC's accumulator always appears with a plus sign is not used in the examples in the text.

A reader who has a particular machine in mind may wish to skip discussion of features which his machine does not possess. He can do so without getting lost. The only price paid for this flexibility is one which an individual reader may not notice but which an instructor using the book as a textbook will need to anticipate. It is not always clear which safeguards need to be incorporated in the answer to a problem and which have been taken care of in the preliminary analysis which would have been carried out if the problem posed had arisen in the course of actual programming.

A concise summary of the contents is given by the chapter headings: computing fundamentals, coding fundamentals, binary and octal number systems, decimal point location methods, address computation, loops in computing, flow charting, index registers, subroutines, floating decimal methods, input-output methods, magnetic tape programming, program checkout, relative programming methods, interpretive programming methods, double precision arithmetic, miscellaneous programming techniques, automatic coding. Appendices give a summary of TYDAC instructions and a brief discussion of minimum access programming and of externally programmed computers. The reader should realize early in his reading that he is expected to use the summary of TYDAC instructions in the appendix as a primary source of information about the instructions.

Digital Computer Programming fills a gaping void among books on computing machines. It will be welcomed by all who wish to know how problems are programmed for a stored program, computing machine.

AUTOMATION IN BUSINESS AND INDUSTRY, edited by Eugene M. Grabbe, 596 pages, $10.00, published by John Wiley & Sons, Inc., New York, 1957. Reviewed by Irwin A. De Grote.

This book is unique in that each chapter, covering the different aspects or phases of automation, is written by a different expert in that particular segment of the automation field.

It covers automation from the "Language of Automation" to the economics and future of plant automation. The major emphasis is on the *control* of automated systems, feedback control systems, industrial instrumentation and control, analog and digital computors, and data processing.

Other chapters cover the automatic control of flight, automatic production of electronic equipment, process control of petroleum and other chemicals, digital control of machine tools, and the control of quality through feedback mechanisms.

It contains numerous illustrations, formulae, electrical circuits, and schematic diagrams covering, mainly, control systems, and electronic computers.

The book should be very valuable to anyone who desires familiarization with the general field of automation, particularly the automatic control and computer field. It is technical enough to supply a complete explanation, yet written so that anyone, familiar with industry or business, should find it informative.

QUALITY CONTROL METHODS AND MANAGEMENT

The result of the symposium held in September at Drexel Institute of Technology and sponsored by the Philadelphia section is nine papers which comprise the "symposium transactions."

These papers present some of the quality control methods that are tools for management and also present some management views on quality control. Here are the subjects covered.

Human Engineering and Quality Control
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Receiving Inspection and Vendor Relations
Quality Control and Reliability
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Chemical Division News

The first annual Technical Conference of the Chemical Division was held at the Benjamin Franklin Hotel in Philadelphia Oct. 18 & 19. An excellent program of fifteen papers was presented during the two day session. The local committee under the leadership of Mr. Hillman Harris performed an outstanding job. The Chemical Division Council meeting the day before the conference laid plans for sponsoring another conference in October of 1958.

CONTROLLING UNDERFILL AND OVERFILL IN PACKAGING EQUIPMENT, Special Report No. 15, American Management Association Inc., 1515 Broadway, Times Square, New York 36, N. Y. Reviewed by Deland H. Davis.

The American Management Association has provided a great service to the Food and Allied Industries, in the assembling and publishing of this extremely practical guide to the requirements, problems, and control of filling operations on packaging equipment. Each section is written by two or more recognized authorities that are currently working in the field that they cover. Practicality and brevity is the keynote throughout. Theory and discussion is almost entirely eliminated, thus providing in a compact and easily assimilated form, a ready reference to the requirements (legal and economic) of fill control, and a presentation of the organizational set-up and the technical procedures used to accomplish these requirements in a wide variety of packaging operations.

The First Section covers, in a clear and concise manner, the legal requirements at both the National and State level. Pertinent extracts of the Federal Food, Drug, and Cosmetic Act are referred to and their legal interpretations regarding net weight or fill, slack fill, and labeling presented. A brief discussion of additives is also given. The variations in State regulations are discussed, together with the efforts now underway to provide greater uniformity between states.

The Second (and most extensive) Section covers the Statistical Quality Control programs now being used in eight typical industries packing products for National distribution. Included are foods (powder, granular, flake, non-free flowing, and liquid), drugs, and toiletries. They present their Quality Control Policy, Organization, and Responsibility. Detailed plans for the studying, evaluating, and placing under control of various types of filling equipment are given. Results obtained and limitations observed are most informative and interesting to anyone faced with packaging problems.

The Third Section discusses in some detail the techniques and equipment now available for checking package fill. The needs for weight control and the most important requirements to consider in establishing control procedures are outlined. This covers systems for both solids and liquids (including X-ray techniques), and suggestions are given for the proper care and maintenance of industrial scales.

Correction Notice

The following is printed to clarify a sentence that appeared in the article "An Evaluation of the Maytag Double-Line Chart" by R. L. Madison and B. Ostle which appeared in the September 1957 issue. On page 11, the second restriction in paragraph number three now reads "that the sample range shall not exceed six standard to one or the other engineering specification limit." The correct wording should be "That the set of sample points shall not lie too close to one or the other engineering specification limit."

Thanks to Contributors

Since the publication of the August issue (and subsequent follow-up in the October issue) in which President Bass extended his official thanks to those sections and divisions who had given contributions to the Society, several more contributions have been received. The Society's official thanks are extended to the following.

Boston	Montreal
Central Illinois	Philadelphia
Cincinnati	Rhode Island
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Chemical Division

These contributions are greatly appreciated by your Society.

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The Fourth Section presents very factual data on the advantages, limitations, and means of controlling Vacuum, Auger, Net Weight, and Gross Weight fillers for solids; and Gravity, Gravity-Vacuum, Rotary Piston, and Pre-determined fillers for liquids. This information, based upon actual operation observations, will be of utmost interest to those faced with the many questions and problems encountered in the packaging of their products.

This publication provides an excellent guide to those confronted with the problems of installing or improving packaging equipment and establishing proper control of the fill produced by this equipment. It is clear, concise, and factual. Each of the nineteen contributors are recognized authorities. They write from practical experience and present information based upon what has and is being done, rather than on what could or should be done.

WORK SAMPLING, by Robert E. Heiland and Wallace J. Richardson, published by McGraw-Hill Book Company, New York, New York, 1957, 243 pages, 6 × 9, bound, price $6.00. Reviewed by Fred A. Beeler.

Work Sampling is a fairly new technique and consequently may not be too well known. According to the authors' definition, "Work Sampling is a measurement technique for the quantitative analysis, in terms of time, of the activity of men, machines, or of any observable state or condition of operation." This technique has proved to be an economical method of measuring the activity in such non-repetitive jobs as: office work, machine accounting, materials handling, department stores, factory operations, machine accounting, drafting departments, plant maintenance, etc. The authors cite as a simple example, an office with several employees has but two telephones. They were asking for another phone and gave what they thought were valid reasons for this request. A Work Sampling study was made on the use of the telephones and the results indicated that both phones were in use at the same time only 0.6 percent of the time. Result: no extra phone.

This book gives a step by step procedure for making a Work Sampling study. There is a thorough discussion for the preparation, performing, evaluating and presentation of study results. Some of the pitfalls that could occur are pointed out and discussed. Such basic statistical tools as ramdom sampling, use of the binomial distribution and confidence limits needed for this type of study are presented. The close relationship between statistical quality control and work sampling is pointed out.

Numerous examples of Work Sampling studies are given, and this does much to clarify the basic principles. The necessary statistical tables are included and there is also a bibliography of articles on this subject.

The authors claim that this brief explanation of these statistical tools is sufficient for the untrained person to carry out a work sampling study but this reviewer believes that the director of such a program would find further study of statistical methods beneficial.

This is a comprehensive "how-to" exposition and should prove to be most useful.

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(23) A. J. Duncan, "Use of Ranges in Comparing Variabilities," Reprint from IQC Vol. XI, No. 5, February 1955	.25
(24) Charles R. Hicks, "Fundamentals of Analysis of Variance," Reprint from IQC Vol. XIII, Nos. 2, 3, 4, August, September, October, 1956	.45

*Vol. I, Nos. 3 and 4 and Vol. IV, No. 2 are now out-of-print making these volumes incomplete.

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ASQC Convention Exposition Chart

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MAY 26 - 28, 1958

HIGHLIGHTS

YOU'LL NEVER FORGET BOSTON—

. . . where Quality Control executives and engineers from all industries will gather next May 26-28 to attend the 12th Annual Convention and Exposition of the American Society for Quality Control. The exposition at Boston's Hotel Statler will feature exhibits of firms using quality control as well as exhibits of companies making quality control tools, instruments, gages, computing machines, management control techniques, and thousands of other quality control items.

EXPOSITION SHAPES UP

M. E. Cunningham Company exhibited for the first time in 1957, and were among the first to reserve their 1958 space. International Business Machines Corporation has increased their 1958 space over space used in previous expositions. Friden Calculating Machine Company, Inc. and Monroe Calculating Machine Company, Inc. were the first computing machine manufacturers to reserve space. The L. S. Starrett Company, Miles Reproducer Company, Inc., Elliott Service Company, and Federal Products Corporation were also among the early space reserving companies. Among the new exhibitors are Keystone Manufacturing Company, Veeder-Root, Inc. and Carl Zeiss, Inc. Space was opened for general sale as this issue went to press.

Advance reservations are an indication that the Boston and New England area is a key market for Quality Control equipment.

TECHNICAL PROGRAM

Outstanding leaders from the United States and abroad will present technical papers covering all phases of Quality Control. The various divisions of the Society assisted in the planning of these subjects which will include aircraft, automotive, metals, textiles, pharmaceutical, brewing, chemicals and many other industries. Job shop applications of Quality Control will also be covered.

You'll hear from top management, quality control managers, and leading experts in the most advanced methods and techniques of Quality Control. Meetings will be scheduled so that all members and guests have adequate time to study the exhibits in the Exposition properly.

DIVISIONAL MEETINGS, PLANT TOURS, SOCIAL FUNCTIONS

Committees are making arrangements for the annual divisional meetings and dinners. Tours are being planned to leading plants and research centers in the Boston area. Detailed announcement on these events will be made after the first of the year.

The social party will feature the old fashioned New England hospitality and will be one long remembered.

TO ASQC MEMBERS:

As a user of Quality Control, your company should exhibit to promote the interchange of technical information on the methods of Quality Control.

Please pass this page on to your sales manager, exhibit manager, or advertising manager so that he can make plans for your exhibit.

Be sure all of your suppliers exhibit!

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